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Compliments of the

Illinois State Board of Health.

James A. Egan, M. D.,

Secretary and Executive Officer.

4-8-13

THE ILLINOIS STATE BOARD OF HEALTH

REPORT

OF THE

SANITARY INVESTIGATIONS

OF THE

Illinois River and its Tributaries

With special reference to the effect of the sewage of Chicago on the Des Plaines and Illinois Rivers prior to and after the opening of the

CHICAGO DRAINAGE CANAL.

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THE ILLINOIS STATE BOARD OF HEALTH, 1901.

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AS AFFECTED BY THE DRAINAGE OF CHICAGO AND OTHER CITIES.

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At a meeting of the State Board of Health, held in Chicago on the 20th day of June, 1899, a resolution was adopted directing the secretary to take immediate steps to cause an investigation to be made of the waters of the Illinois river, with a view of determining its condition under the circumstances then prevailing, and which would obtain, subject to the changes incidental to the different seasons, until the quantity of water was increased by the opening of the canal under construction. The resolution also directed that the investigations be continued after the opening of the canal, until sufficient information was available to enable the board to judge whether the condition of the water was improved by the augmented flow.

To properly conduct these investigations the secretary secured the services of Professor John H. Long, of the Northwestern University, whose analyses of the waters of the Illinois and Michigan canal and of the different rivers of the State have received favorable notice in the majority of publications on the purification of water supplies and sewage disposal at home and abroad, and of Mr. Jacob A. Harman, civil engineer of Peoria. To these gentlemen was intrusted the duties in the lines of their respective professions, and their reports are herewith submitted.

A preliminary report containing the results of investigations made in 1899 prior to the opening of the canal was published early in 1900. The following reports embrace the essential facts found in the preliminary report and also the results of investigations conducted during the year 1900, since the 17th of January of which year the greater part of the sewage of Chicago has flowed through the Chicago drainage and ship canal.

Professor Long has been assisted in the identification of the species of bacteria found in the Illinois river and its tributaries, by Professors F. Robert Zeit and Gustav Fütterer, both of the Northwestern University Medical School, who have submitted a separate report in detail.

The State Board of Health, while entrusted with "the general supervision of the interests of the health and lives of the citizens of the State" and empowered to make such rules and regulations and

such sanitary investigations as may from time to time be deemed necessary for the preservation and improvement of the public health, lacks the necessary authority to absolutely protect the purity of the water supplies of the State and enforce suitable disposal of sewage and other waste. Efforts have been made from time to time to secure the enactment of legislation conferring upon the board sanitary supervision and control of all sources of water supply within the State, and of the methods and means of collection and disposal of sewage, but bills embodying the further authority sought have rarely got beyond the room of the committee to which they were referred.

Notwithstanding the absence of specific powers and the lack of an adequate financial appropriation, the board, acting in an advisory capacity, has contributed much to the material progress of better sanitary methods, and especially to securing a pure water supply for many cities in the State, particularly Chicago, which, being the most populous and rapidly growing city in the west, has justly demanded and received more attention from the board than any other.

An investigation and study of the best means attainable of improving the water supply of this city were among the earliest efforts of the board, and it may be interesting to give here a resumé of the report on the subject by the secretary, the veteran sanitarian, the late Dr. John H. Rauch, whose achievements in the cause of sanitary science and in the advancement of medical education are too well known to need direct reference in these remarks. This report, which was made to the board shortly after its organization, was prefaced by the following extract from Dr. Rauch's report upon Drainage, rendered while sanitary superintendent of the city of Chicago in 1869, which is taken from the preliminary report to the Illinois State Board of Health on the Water Supplies of Illinois and the Pollution of its Streams, prepared by Dr. Rauch and his distinguished collaborator, Dr. Frank W. Reilly, now assistant commissioner of health of Chicago, who was connected with the board from the time of its organization until 1893:

> From the results of drainage and other sanitary measures carried on in this city, it may be inferred that the judicious expenditure of money for sanitary purposes is a sound maxim of municipal economy, and from past experience I am satisfied that the mean annual death rate can be reduced to 17 per 1,000 by continuing in force the present sanitary and drainage regulations, thereby making Chicago one of the healthiest cities in the world.

This was written at a time when the average annual death-rate of Chicago was over 24 per thousand. Within the subsequent decade the average annual death-rate had been reduced to 18.48 per thousand, and in 1878 it had fallen to 16.5, or less than the predicted 17 per thousand.

The first report of the secretary embraced the general results of over twelve years of previous study, and specifically of investigations begun under the auspices of the board in October 1877, covering the amount and sources of the Chicago sewage, its flow through the canal and extent of dilution, effects of varying lake levels, force and direction of wind movement, temperature, precipitation and other meteorological factors, and chemical investigations of waters collected at various points between Lake Michigan and Peoria. The following

prefatory paragraphs are given in full as showing the comprehension of the importance and magnitude of the undertaking at that time. The report was addressed to the Illinois State Board of Health:

GENTLEMEN—In pursuance of your instructions, and in the sanitary interests of the State, I have devoted all the spare time that I could to the consideration of the pollution of streams, and especially to the effect of the Chicago sewage on the Illinois river.

The following report, which is submitted at this time because immediate action is necessary, contains the substance of my investigations and the conclusions arrived at thus far; but it is only preliminary to a more comprehensive one which I design to submit to you at a future time.

The factors connected with the drainage of Chicago, through the Illinois and Michigan canal, are many and of a diversified character. To accurately determine the relative effect of each, as meteorological changes occur during the year, requires the closest study and involves much labor. The importance of the subject can not be overestimated, for it involves the sanitary well being and comfort of at least one-third of the population of the State. I have also conducted similar investigations with regard to the pollution of the Sangamon river, from which the water supply of the city of Springfield is obtained, and of Cahokia creek, at East St. Louis.

A SKETCH OF EFFORTS MADE TO CLEANSE THE CHICAGO RIVER.

From the earliest days in the history of Chicago, the Chicago river has attracted anxious observation from a sanitary standpoint, and the anxiety has increased with the increased population of the city and the suburbs, especially since the river has been the receptacle of a large part of the sewage. When a more perfect system of sewerage became imperatively necessary for the health of the city, the widening and deepening of the Illinois and Michigan canal to the capacity of a ship canal was suggested as a means of at once facilitating the commerce of the city and lakes and purifying the river. The one was urged as a proper national enterprise, and the other as a vital necessity for the increasing population of the locality. In July, 1860, the Sewerage Commissioners of Chicago recommended that the canal be enlarged and deepened so as to create a constant current from Lake Michigan into the Illinois river, but action upon their suggestion was not deemed necessary at that time. The pollution of the river increased, however, beyond all expectations, not only by reason of the increase of population, but from other causes. Among the latter was the increase in the slaughtering of hogs and cattle and the packing of meats. In the year 1860, 306,428 head of cattle and hogs were killed and packed, and all of the offal was passed into the sluggish river. In 1863 this business had increased enormously. In that year the number of cattle and hogs slaughtered increased to 1,029,948, and the offal was still swept into the river. There has been a vast increase, year by year, in this business ever since, keeping pace with, or even exceeding, the increasing volume of sewage produced by the rapidly growing population. This accumulation of sewage was partially relieved by pumping-works at the head of the canal; but the relief so afforded could not keep pace with the increase of sewage and offal, and in 1863 a remarkable epidemic of erysipelas occurred, which prevailed exclusively in close proximity to the south branch and to the main river. The great amount of animal refuse thrown into the south branch was supposed to have been the cause of this epidemic. The pollution of the river from these causes increased daily, in 1863 and 1864, and on Jaunary 9, 1865, a commission of engineers was appointed 'to devise the best plan to cleanse the Chicago river.'

This commission presented their report on March 6 of that year, and, after discussing several projects, recommended that, 'in view of the facts in the case, the best plan to cleanse Chicago river that we can devise is to cut down the summit of the canal, so as to draw a sufficient quantity of water through it from the lake to create the necessary current in said river.' It was urged, as an argument in favor of the proposition, 'that the money expended in cutting down the summit of the canal will constitute a part of the expense of enlarging the present canal so as to admit the passage of steamboats of the

largest class, an improvement that must soon be made.' This plan was adopted, and, in the fall of 1865, the work of deepening the canal was commenced. It was completed in 1871, and, in July of that year, water was admitted at the deep cut from the river. The cut so made at the head of the canal was six feet, and it was computed that at an ordinary stage of water twenty-four thousand cubic feet per minute would flow from the river into the canal.

EFFECTS OF PUMPING THE RIVER INTO THE CANAL.

From the year 1860 to 1865 the pumps at Bridgeport were only used to supply to the canal such water as was needed for navigation, and their action in purifying the river, though marked and valuable, was only incidental. But in the latter year the Board of Public Works made an arrangement with the Canal Commissioners to utilize the pumping works as much as possible for the cleansing of the river. It happened, however, in that year, that unusual rains kept the river in fairly good condition without this extra use of the pumps. But the arrangement was maintained, and in 1866 the pumping works were in operation for sixty-two days; in 1867 they operated one hundred and fifty days; in 1868, seventy-three days; and in 1869, one hundred days. The amount of water raised eight feet by them in 1869 is estimated at ten thousand cubic feet per minute. The effect of their operation was marked and favorable, but the result was affected by the operation of other causes, which at times aided and at others hindered the purification of the river. These causes were the variation in the lake level, the local rains, and especially the constant increase of sewage and offal, resulting from the increasing population, and the slaughtering, and other business interests.* These influences were constantly operating, and it was found necessary to increase the use of the pumps each year, as is shown in the figures stated above, whenever possible, owing to the limited capacity of the canal, which also depended upon the rainfall. As the population increased, and, necessarily, the amount of sewage also, the effect of the pumps in cleaning the river was less marked.

After the water was let into the 'deep cut,' in 1871, it purified the south branch and the main river, but it was soon discovered that it effected no marked change in the water of the north branch. The latter continued to be so foul that in 1873 the Fullerton avenue conduit was begun, with a view to its purification. About the time the deepening of the canal was completed, the slaughtering business was transferred to the stock yards, whence the drainage is into the south fork of the south branch, and it was soon apparent that the drainage afforded by the 'deep cut' and the canal had but little influence in carrying off the drainage of these establishments, though, owing to local and transitory causes, the water in the south fork was occasionally cleansed.

The discussion, which follows in the printed report,† of the causes which affect the flow of water from the lake into the canal, the varying lake level, rain-fall, barometrical pressure and consequent wind movement, the flow through the canal, the analyses of the water and general observations, can not be given here owing to the lack of space. But the concluding passages of the report, having reference to a recommendation to the city of Chicago urging the establishment of the pumping works at Bridgeport may properly be cited at this point. The report concludes as follows:

This will be the first time that the Board has made a recommendation to the city of Chicago in relation to its sanitary affairs. There is another view of the case to which the attention of the municipal authorities of Chicago should be called, which is, that that city has no right to unnecessarily injure

*It is gratifying to be able to here note, that, notwithstanding the enormous increase of the slaughtering business in Chicago within the past few years, the nuisances incident to rendering and utilization of offal have been diminished.

†Second Annual Report Illinois State Board of Health, 1879, pages 110-18.

the material and sanitary interests of any other part of the State. The community of interests which exists between the citizens of Chicago and the inhabitants of the country lying along the canal and river, forbids the injury of either by the other.

It is but just to state that the plans heretofore adopted for the sewage and drainage of the city of Chicago have been made with a view to such change as the future might require. The deepening of the canal, which was begun in 1865, was not completed until 1871, so that the relief afforded by that measure was delayed six years from the time when its necessity was recognized. The pumping works can be rebuilt in ninety days. My reasons for recommending this course are that the works will furnish almost immediate relief without great expense, and without interfering with the project of a ship canal, or with any more permanent plan which may become necessary for the disposition of the Chicago sewage.

That the oxidation of organic matter is promoted by the process of pumping will be seen by comparing the analyses of specimens Nos. 16 and 17. No. 16 was taken from the mouth of the inlet pipe at the Peoria water works, and contained 83 parts of organic matter in a million parts of water, while No. 17, which was taken on the same day, several hours later, after the water had passed through the works, contained only 54 parts. Specimen No. 19, taken from the Sangamon river, below the paper mill and distillery, and several miles above the Springfield water works, contained 126 parts; while specimen No. 20, taken from the office of the Board at the State House, contained but 73 parts. Specimen No. 28, taken from the inlet pipe of the Springfield water works, on December 1, (1878), contained 86 parts, while No. 29, taken from the office of the Board, contained but 54 parts.

The agency of the pumps in promoting oxidation will be more needed in winter than in summer, because, among other things, in summer the stirring of the water in the canal by the passage of boats promotes oxidation, in some degree at least, but, more importantly, because low temperature retards oxidation. I remark that any other plan that will afford relief will involve a much larger expense than this will, and much longer time to effect the result. The cost of the pumping works, which were erected by the State in 1859 and 1860, to supply the canal with water for the purposes of navigation, was $42,158.24. From the statement of their operation, contained in the reports of the Canal Commissioners, I have computed that they raised about ten thousand cubic feet of water per minute eight feet high. The building yet remains, though it is leased to private parties for a short time. I have no doubt that an arrangement could be made with the Canal Commissioners for its use without any expense to the city of Chicago. I am informed that the old lock can be restored at a cost of not more than $10,000. If the whole expense of re-erecting the works should be $60,000 or $70,000, and the expense of operating them should amount to $100 per day, it would be trifling compared to the benefits which would result. I am satisfied that an equitable arrangement can be made with the Canal Commissioners for maintaining the works. The fall from the head of the canal to Lockport, a distance of twenty-nine miles, is three feet, and the current between those points has a velocity of half a mile per hour at this time. The velocity will increase in proportion as the water at the head of the canal is raised, and the increase will promote the oxidation of sewage. After a careful investigation, I am satisfied that, with fifty thousand cubic feet of water passing into the head of the canal per minute, the main river and the south branch will be purified; that no nuisance will result from sewage at Joliet and below, and that the potability of the water in the Illinois river at Peoria will not be in the least affected from that source. An increase of water to sixty thousand cubic feet per minute would, in my opinion, take in addition the sewage of the north branch after it has once been cleaned out, and would diminish the nuisance in the south fork of the south branch at least three fourths.

I am informed by practical men that the increase of current in the canal, which would result from this increase of water, would not materially interfere with navigation, because of its increased depth. The lake level is lower now than it has been for a number of years; but, judging by the experience of the past, it will begin to rise within a year, and will continue to rise

during a number of years. But no improvement in the condition of the water in the canal and river can be expected from this cause, for the increased flow into the canal which the higher lake level will produce, will not keep pace with the increased sewage.

The Fullerton avenue conduit is now completed, and an experimental test will soon be made. I do not share in the great apprehension that exists in the minds of many with regard to the effect upon the pollution of the water supply of the city of Chicago, if the water is pumped from the north branch into the lake, at present; but I think it probable that, under certain conditions, it may pollute it.* Pumping water from the north branch into this conduit will necessarily cause a flow of water from the main river into the north branch. How far this will affect the flow of water into the south branch from the main river under existing circumstances, I am not prepared to say; but I do not hesitate to say that when the current is toward the lake, it will be almost impossible to purify the north branch in this way, for the sewage of both the main river and the south branch will then flow into it. The water in the north branch, north of the conduit, is much less foul than that further south, and it is with special reference to the purification of the latter that the conduit was constructed. But under certain conditions it will happen that the effect of pumping will be to draw off the comparatively clean water at the north end of the branch without materially affecting the fouler water below, as when there is a considerable supply of water by rainfall draining into the branch, which does not amount to a freshet, and changes in the lake level from any cause may also produce this effect. Of course when there is a freshet out of the north branch the operation of the pumps is not needed for its purification. At times when the water is pumped from the lake into the north branch its effect will be to create a current into the main river and thence through the south branch into the canal, diminishing or at times cutting off the supply of water which otherwise flows from the lake into these channels. This will add the sewage of the north branch to that of the south branch.

I have already shown that the current into the head of the canal, under the most favorable circumstances, barely keeps the main river and the south branch in a tolerable condition. The addition of the sewage of the north branch to the south branch would render the lower portions of the latter nearly as foul as the north branch now is. In other words, it would only amount to a transfer of the nuisance and an increase of the nuisance at Joliet and the pollution of the Illinois river. At other times, the effect of pumping water from the lake into the north branch, will be to carry the sewage from the latter into the lake through the main river, and when the current is sluggish to cause the latter and, to some extent the south branch, to become foul and offensive. Either way, the sewage will at times find its way to the lake. If it is desirable or necessary to prevent this, it can be done by increasing the flow of water from the lake into the canal, and it can be done in no other way.

It is better for the city of Chicago that all the sewage should pass into the canal, but it should be so diluted as to prevent injury to the sanitary condition of the country below. If 60,000 cubic feet of water per minute at the head of the canal will not create the necessary current to effect this purpose, I have only to remark that the amount may be increased up to 100,000 cubic feet, which, according to Mr. Thomas, is the present capacity of the canal. Ever since 1872 the south fork of the south branch has been a standing menace to the health of the city of Chicago. Frequently, when foul odors are blown across the city, characterized by a peculiarly sickening, deadening stench, and attributed to the slaughtering, rendering, and fertilizing establishments, it really comes from this source. For the purification of this, which is one of the foulest bodies of water within my knowledge, various plans have been proposed; among others, the construction of a large sewer and pumping works, for conveying the water either into the lake or the canal. The condi-

* While the Fullerton avenue conduit pumped from the north branch into Lake Michigan, complaint was several times made that the water supply of Lake View was polluted by it.

tion of this water will be appreciated better than any words can possibly describe it by reference to the analyses of specimen No. 1, from the head of the south fork, which contained 539 parts of organic matter in a million, and specimen No. 2, from near the mouths of two sewers, which contained 1,233 parts, while specimen No. 4, from the south branch before its junction with the west branch and south fork, contained only 74 parts per million. From the location of the old pumping works, on the same side and near the mouth of the south fork, I am satisfied that the pumping works will, to a great degree, purify this water. Specimen No. 3 was taken from this fork at the Archer avenue bridge, some distance from its mouth, and contained only 125 parts, showing the purifying effect of the lake water passing through the south branch to the canal.

All of which is respectfully submitted,

JOHN H. RAUCH, M. D.

To the copy of this communication, as printed in the Second Annual Report of the State Board of Health, is appended the following note by the Secretary:

NOTE.—By direction of the Board a copy of the above report was submitted to the Mayor and Common Council of the city of Chicago, on January 12, 1880, and in order to carry out the recommendations therein contained, an appropriation of $100,000 was made by the Common Council for the purpose of constructing pumping works at the head of the canal. While the matter was pending before the Council, the subject was widely discussed by the press, the Chicago Citizens' Association and the Engineers' Club; conferences were held between the State and city authorities, and an important convention was held at Ottawa looking to pushing the construction of the ship canal from Lake Michigan to the Illinois river. While this last would undoubtedly afford an adequate and permanent method of disposing of the sewage of Chicago, (provided, that such canal be made wide and deep enough to properly dilute the sewage,) and while possibly some of the numerous other plans which have been since suggested would achieve the result sought for, I see no reason for modifying my conclusion above given, namely, 'that this resort to pumping is the only plan which can be adopted with sufficient promptitude to accomplish the desired end at an early day.' It is immaterial whether this pumping be done from the south fork through a canal connection via the stock yards, or by works located at the Ogden ditch and emptying into the Des Plaines river; or, as is specifically suggested, by re-establishing the pumps at Bridgeport. If this last be done so as to secure a capacity of 60,000 cubic feet per minute when desired, the facts and figures cited in the report demonstrate that substantial relief will be secured for some time to come. With the growth of the city and consequent increased production of domestic and manufacturing wastes and refuse, the time will arrive when 60,000 cubic feet per minute will not dilute the sewage to the point of inoffensiveness, but when that time arrives additional works may be constructed at Ogden ditch with a capacity of say 150,000 cubic feet, and with these two systems the sewage of a population of a million and a half may be satisfactorily disposed of. The vital point now is speedy relief from a grave sanitary danger; one which not only effects Chicago, but which either threatens to, or actually does, pollute the water supply of neighboring communities; which seriously menaces the health of the river towns, and poisons the atmosphere many miles south of the source of the evil. Does not Chicago owe it to herself and to her neighbors to act promptly and efficiently in the matter? Can she afford to invite not only epidemic diseases but an increased death rate? Can she afford to still further incur the risk of pollution of her own water supply, and that of her neighbors on the lake? From the data presented in the foregoing pages it seems obvious that only one available remedy exists for these imminent evils, namely, the removal of her sewage, properly diluted, by the water courses flowing toward the Mississippi river.

At a meeting of the Board on June 24, 1880, the Secretary resumed the subject* and again urged the speedy construction of the pumping works as a sanitary necessity. The following extract from the report of Dr. Rauch will be found interesting:

Within the last week I have made a careful inspection of the Chicago river and found it fouler and more offensive than it has been at any time since the deep cut was completed in 1871, and I only recollect of one other time (1869) when it was worse, and then only for a short time, as the pumping works were set in motion and soon improved its condition. In the main river the current was toward the lake, showing that but little change had taken place in the lake level. At Van Buren street the water was practically stagnant; at Eighteenth street there was no current, and at Halsted street, for the first time within my knowledge, I observed no current toward the canal. (This is unusual except when a freshet occurs.) The south fork of the south branch was, comparatively speaking, in good condition, owing, no doubt, to the late rains. There was a decided current at the mouth of the canal, and upon further examination I found that the canal was taxed to its capacity by the water of the west branch and the south fork, thus causing the condition at Halsted street, and as far south as Van Buren street. The north branch at Kinzie street was also very foul, with a slight current toward the lake. In fact, at no time since the deep cut was completed was the water of the entire river so sluggish. About two months ago I called upon the mayor of Chicago and had an interview with reference to the construction of pumping works. The effect of the Fullerton avenue pump has been just as predicted in my report written before the pumping commenced, and without the construction of the pumping works at Bridgeport it will only partially remedy the trouble.

It might well be stated here that owing to the persistent recommendations of Dr. Rauch, fortified by the opinions of competent observers, that the only remedy for the conditions existing lay in an increased flow of water into the canal—and strengthened also by the protests of cities receiving the drainage of Chicago, and a tentative proposition to compel the city to dispose of its sewage in another manner than by discharging it into the canal—steps were taken in 1881 to cause an increased flow from the Chicago river into the canal. This was accomplished by a joint resolution of the Senate and House of Representatives in May, 1881, which provided for a flow of not less than 60,000 cubic feet per minute, the city of Chicago being required to maintain and manage adequate pumping works. For two years after the construction of the pumping works in 1884, the river and canal seemingly were kept in an unoffensive condition, but later, owing to the continual lowering of the lake level the force of the pumps soon became inadequate, and the water in the canal resumed the state existing prior to the construction of the works.

The work begun in 1877 was continued by the board for some time, but in a desultory manner, occasioned by the lack of means, and it was not until 1885 that the Legislature appropriated a contingent fund sufficient in amount to justify the board in securing the services of professional analysts, observers and other indispensable assistants.

The results of the work accomplished with the means at hand have been published in the annual reports of the board. The most im-

*Third Annual Report Illinois State Board of Health, 1880, page 15.

portant of these results are to be found in the eighth annual report, 1885, pages CXVI-CXXVIII, the ninth annual report, 1886, pages XIII-XIV, XXIX-XXX, XXXIX-LIX, LXIV-LXVI, tenth annual report, page X, and in the Preliminary Report to the State Board of Health on the Water Supplies of Illinois and the Pollution of its Streams, published in 1888.*

While the subject now is of but little concern to the people of Chicago, and a recital of the facts can awaken but a faint interest elsewhere in the State even among the inhabitants of the lower valley, it may not be out of place to state that methods "to dispose of its sewage in another manner than discharging it into the canal" were considered at length by the city of Chicago. In January, 1886, the city council passed a resolution authorizing the creation of a drainage and water supply commission which was empowered to consider the entire subject of the future water supply and drainage of Chicago, and if possible, to devise means to remedy the existing inadequate methods of drainage and sewage disposal. In a preliminary report made by the Commission in January, 1887, after a year's investigation, it was stated that among the possible methods of getting rid of the Chicago sewage, there were but three that had been deemed worthy of an extended consideration, namely, a discharge into Lake Michigan, a disposal upon land by filtration and irrigation and a discharge into the DesPlaines river. A copy of this report embodying a full consideration of the different methods proposed may be found, with other valuable information concerning the subject at issue, in the work entitled "Drainage Canal and Waterway," by G. P. Brown, published in 1894.

The work of the Commission, while not carried to a conclusion owing to the refusal of the city council to appropriate the necessary funds, can, nevertheless, be considered final so far as a consideration of the most feasible means of the disposal of sewage is concerned. The conclusion arrived at is substantially the same as that set forth in the first report of Dr. Rauch to the State Board of Health on the subject, viz.: "the removal of her (Chicago's) sewage, properly diluted, by the water courses flowing toward the Mississippi river."

As stated by Dr. Rauch in the preface to his report in 1889, it is apparent that the Commission was strongly in favor of the method of disposal by land, and only abandoned it when it became obvious that suitable land in sufficient quantity was not available within the borders of the State at any practicable distance, and even though available territory were obtained in Indiana the enormous cost incident to the construction of the necessary intercepting sewers and the lifting and transporting of the sewage for several miles, would render the project impracticable. Given a suitable body of land, the plans of the Commission for the disposal of the metropolitan sewage alone, by intermittent filtration and sewage farming, would require an investment of about $58,000,000, with an annual expense of over $3,000,000 for interest, pumping and maintenance after deducting

* Also Advance Notes of the Sanitary Investigations of the Illinois River and its Tributaries, Illinois State Board of Health, 1900.

the profit from sale of crops. The disposal of the sewage of the Calumet region would add about $4,000,000 to the cost of this plan, or a total of $62,000,000, and would increase the annual expense about $250,000.

The Commission finally approved of the project for the construction of an artificial waterway capable of carrying 600,000 cubic feet per minute, from the south fork of the Chicago river to Joliet. This quantity of water per minute represents 6,480,000,000 gallons per day. Concerning this Dr. Rauch thus wrote in 1888: "If we admit that the ultimate population in the area to be drained will reach 2,500,000, and that its average sewage product (150 gallons per head) will amount to 375,000,000 gallons per day, this quantity—6,480,000-000 gallons—would give a fraction over 17 dilutions, or more than sixteen parts of lake water to one of sewage, instead of two parts of lake water to one of sewage as now. It is to be noted that this would be the minimum dilution, and not likely to be reached until some time between 1910 and 1915."

Notwithstanding the conclusion of the Commission that the adoption of a system whereby the sewage of Chicago might be disposed of by land irrigation and filtration was impracticable, it should not be determined that the system, *per se*, is at fault. Means to this end have been in vogue in several European cities for a number of years, and are reported to have resulted very satisfactorily. Many municipalities in the United States also have adopted this method of disposing of their sewage by establishing proper plants.

Among these, however, which were recently reported as working satisfactorily, is mentioned the sewage farm at Pullman (Chicago) Ill., discontinued years ago, and which, during its existence, could not be referred to as a particularly successful example of sewage purification. It is to be hoped that the reports of other "sewage farms" are more trustworthy than that of the model village of Pullman, established nearly twenty years ago.

The methods in operation in both Berlin and Paris have been and still are cited as examples of perfect disposal of sewage, yet as in years past, there are still grave doubts as to the reliability of this plan for the disposal of metropolitan sewage. In this connection reference can aptly be made to the report of the Royal Commission on Metropolitan Sewage, which will be found on page XXIV of the Preliminary Report to this Board in 1888, and the following conclusions of the writers of the latter:

"For small towns, where suitable land is available in sufficient quantity within a reasonable distance; where the storm water is excluded from the sewage; where the effluent may be properly disposed of; where there is no danger of contaminating the subsoil waters by percolation nor other water supplies by surface drainage; where scrupulous care may be continuously exercised and an adequate plant is provided—under such circumstances this system should give fairly satisfactory results. But even at Pullman, where the most favorable conditions obtain, the permanent and unqualified success of the experiment is open to question."

The early reports regarding the Pullman sewage disposal plant were very encouraging, but it was soon discovered that the soil was not suitable for continuous use and that especially during the winter the ground clogged and the sewage flowed direct to the lake. The conditions, therefore, which were regarded as so favorable to success were favorable only in so far as the mechanical arrangements for handling the sewage was concerned, but the disposal beds were wholly unsuited to the service.

It is possible, and in the opinion of many competent observers probable, that at some future period, perchance within the ken of the present generation, the city of Chicago, taking advantage of the improved methods for the disposal of sewage which have been brought to the knowledge of sanitarians since the inception of the great project, the possible realization of the dream of Joliet, will divert its noxious wastes from the waters of the canal and dispose of them, to a financial advantage, in a manner not tending to create a nuisance, pollute the soil, nor prove detrimental in any manner to the public health. Be this as it may, there can be no question as to the wisdom of the conclusions arrived at in 1887 by the Drainage and Water Supply Commission of Chicago.

The opening of the canal and the contemplated turning of the entire sewage of the city of Chicago into the Des Plaines and Illinois rivers, has naturally caused much apprehension in the minds of the people of the Illinois valley who have been informed that this "dumping of sewage" will be a constant menace to the lives and health of the inhabitants of the borders of the rivers in question. Those who have imparted this information ignore the palpable fact that for a considerable period over three-fourths of the sewage of Chicago has been carried by the river with but small dilution of water. Obviously, therefore, the danger, if existing, could not but be diminished when the entire sewage of the city diluted by a flow of from 300,000 to 600,000 cubic feet of water per minute, passes by.

On the topic of self-purification of water much has been said and much written, and while there is still great diversity of opinion on the subject, it is not a fact as stated recently by a noted sanitarian before the American Medical Association, that "biologists have about come to the conclusion that no river is long enough to purify itself."

As remarked by Thresh in the latest revision of his work on Water and Water Supplies, "the balance of evidence is decidedly on the side of those who uphold the theory of self-purification, and the diverse conclusions arrived at by different observers, can be accounted for by the varied and often imperfect character of the experiments and by the diverse conditions which obtain in the different streams."

Again quoting from Thresh: "That river water grossly befouled by sewage in its higher reaches, becomes a few miles lower down so pure, from a chemical point of view, as to be certified by the most eminent analysts to be fitted for all domestic purposes, and is actually so used by millions of our population, is a fact which can not be gainsaid. Whether this process of purification be due merely to

sedimentation and dilution, or to these factors, assisted by oxidation, is, however, a matter of trifling importance, since it is now fully recognized that the disease-producing material is not the dead organic matter in solution, but the living organisms in suspension. The problem is not a chemical one but a biological one. If the specific disease-producing bacteria can be carried long distances by streams, it matters very little whether they are accompanied by an increased or decreased amount of the soluble impurities which were introduced therewith."

Those who oppose the idea of the self-purification of any stream, quote at length, in defense of their position, from the published results of experiments conducted in years past by noted observers, and dwell particularly upon the Sixth Report of the Rivers Pollution Commission of Great Britain, in which the Commissioners, as a result of their experiments, came to the conclusion that there was "no river in the United Kingdom long enough to effect destruction of sewage by oxidation." These views, however, are not in accord with modern experience. At the time the experiments were conducted, the part played by the minute forms of vegetable and animal life in the process of purification was unknown. Many of the experiments recorded have therefore but little interest at the present time.

On this point a quotation from a recent, authoritative, work on the subject, "The Purification of Sewage and Water," by W. J. Dibdin, F I. C., F. C. S., may be apropos.

"A few years ago it was stoutly denied that rivers had the power of purifying themselves. Then we knew practically nothing of nature's method. Now, that this has been so far revealed to us, it is declared with equal force that not only are effete matters rendered innocuous, but even disease-producing microbes are themselves voraciously devoured by others of like kind, and the formerly much-dreaded bacteria are—and properly so—considered amongst the best friends of man."

That the water which forms the principal subject matter of these remarks, viz: that flowing between the south branch of the Chicago river and Grafton, is subject to self-purification, is a proven fact. The experiments of Professor Long in this connection conducted in 1886, are well known to all sanitarians, but a brief resumé of the facts will be of interest here.

During the remarkably dry season of 1886 advantage was taken of the conditions prevailing, to determine the rate of purification of the water of the Illinois and Michigan canal to the Illinois river, in the months of June, July and August. The rainfall was so light during the months named that the contents of the canal were practically unaffected by dilution. Analyses were made of the sewage contents of the Illinois and Michigan canal and of the water of the Illinois river as far south as Peoria.

The following table gives the averages of the different analyses of samples collected at each place on the same day:

Places.	In 1,000,000 Parts.		
	Free Ammonia.	Alb'm'd Ammonia.	Oxygen used.
Bridgeport	26.563	1,633	26.20
Lockport, 29 miles below	12.733	.753	11.01
Joliet, 33 miles below	9.426	.432	9.34
Ottawa, 81 miles below	.413	.243	5.30
Peoria, 159 miles below	.027	.194	4.81

The respective percentages of loss shown in the following may be taken as the measure of the rate of oxidation in the canal during the summer months, unaided by dilution:

Places.	In 1,000,000 Parts.					
	Free Ammonia.	Per cent of loss.	Alb'm'oid Ammonia.	Per cent of loss.	Oxygen used.	Per cent of loss.
Bridgeport	26.563	....	1.633	....	26.20	....
Lockport	12.773	52.1	.753	53.9	11.01	58.0
Joliet	9.416	26.1	.432	42.7	7.34	33.4
Total per cent of loss between Bridgeport and Joliet	64.6	....	70.36	....	72.0	....

In reference to these figures, Dr. F. W. Reilly, under whose direct supervision the analyses were carried on, speaks as follows:*

"The collation of Prof. Long's analyses between Bridgeport and Peoria enabled me to show that more than one-half the sewage pollution of the canal disappeared before reaching Lockport; nearly one-third of the remainder was lost in the next four miles, or 33 miles from Bridgeport; while at Channahon, 48 miles from the city, no trace of sewage was detected. These results were so unlooked for that Dr. Rauch hesitated to accept them. Water analysts had asserted that the self-purification of a polluted stream was impossible —as one phrased it, 'no river in the world is long enough to purify itself after it has been contaminated with organic matter.' In his article on 'Water,' in the Reference Hand Book of the Medical Science (Vol. VII, page 714), that distinguished authority, Surgeon Charles Smart, U. S. A., with whom the writer was associated, together with Deputy Surgeon-General John S. Billings, U. S. A., and Col. George E. Waring, Jr., in the sanitary regeneration of the city of Memphis after the terrible yellow fever summer of 1878—Dr. Smart makes the following comment touching this matter:

'These statements would be of immense importance, were they sustained by collateral evidence; but, unfortunately those analysts who

* "Relation of the Medical Profession to the Water Supply of Chicago," a paper read before the Physicians' Club of Chicago, November, 1896.

have had much practical experience in following the track of sewage in its passage down stream, will recognize in these results: 1. The analysis of a fresh and turbid sewage at the starting point, the solid particles of organic matter giving a high rate of impurity. 2. The analysis of a partly sedimented sewage as those particles disappear from the water. And 3, the dilution effected by the DesPlaines river.'

"To this I felt constrained to make the following reply in the Preliminary Report to the Illinois State Board of Health on the Water Supplies of Illinois and the Pollution of its Streams, April, 1889:

'For the benefit of 'those analysts who have had much practical experience in following the track of sewage in its passage down stream' it should be stated that: 1. The analysis itself, showing 12.6 parts of free ammonia per million, is that of anything but 'a fresh and turbid sewage at the starting point'; on the contrary it is a sewage in an advanced stage of decomposition. 2. Sedimentation in a current with the velocity of that in the Illinois and Michigan Canal is a physical impossibility, and this entirely apart from the influence of the passage of boats. 3. It is expressly stated in the text quoted by Dr. Smart that there was 'no dilution of the contents of the canal,' which contents were the sole subject of the various analyses at Bridgeport, Lockport and Joliet; as a matter of fact the DesPlaines river above the point of junction with the canal had ceased to exist as a watercourse during the period under observation—which was one of unprecedented drought—and the contents of the canal were undiluted from any source after leaving Bridgeport.'

"The demonstration and its deductions were of such obvious—such 'immense importance,' to borrow Dr. Smart's phrase, that the analyses were repeated in the winter of 1886-7, again in the summer of 1888 and still again in the spring of 1889, with substantially similar results in every case."

The results referred to suggest conclusions directly in line with those of other investigators, and are in harmony with the opinion of Pettenkoffer, to the effect that ordinary sewage may be, without hesitation, turned into any river or brook whose volume is fifteen times the volume of the sewage, and whose velocity is not less than that of the stream of sewage. Under these circumstances the necessary dilution and self-purification take place after a short flow.

Mason* while declaring the theory of Pettenkoffer to be far from safe in practice, and expressing the belief that self-purification of streams is a process not to be implicitly relied upon, nevertheless takes occasion to state that judging from the mean results in the experiments conducted, "there is good ground for the statement that very considerable purification takes place during the flow of thirty-three miles."

Commenting upon these experiments, Mr. George W. Rafter in his report on Sewage Irrigation to the United States Geological Survey, in 1897, while admitting that "the investigation indicated a very

*"Water Supply," William P. Mason, New York, 1896.

rapid purification of the sewage-contaminated waters of the present Illinois and Michigan Canal as they flow to the south" states that the "investigations have not been carried far enough to indicate what the results will be upon the Illinois river and the Mississippi when the project (i. e. the canal) shall have been completed and the sewage of Chicago largely turned south."

It is difficult to conjecture just to what extent investigations could have been carried prior to the opening of the canal in order to definitely determine what the results would be thereafter, but it is believed that the investigations of Professor Long* made in 1899 will furnish all possible data on the subject.

The results obtained in this series of chemical and bacterial investigations were published in 1900 in the "Advance Notes" referred to in the foot note. Most of the data in connection therewith and the conclusions arrived at are set forth in this report.†

As bearing on the purification of the waters between Bridgeport and Lockport during the period of these investigations attention was called by Professor Long to the remarkable condition existing in the canal between Bridgeport and Lockport during the summer. Ordinarily in the warm weather there is a marked oxidation here with evident destruction of organic matter. This was shown in the investigations of 1888 and in striking degree in those of the summer of 1886. In the cold winter and spring months of 1889, on the contrary, the oxidation was slight between Bridgeport and Joliet, and this is probably the normal low temperature condition. From the figures given it is plain that the oxidation changes were very slow in the beginning during the summer. In fact, as measured by free and albuminoid ammonia and oxygen consumption, the Lockport water appeared even slightly more contaminated than that from Bridgeport. The amounts of chlorine given by the averages suggested a slight degree of concentration by evaporation between the two places. For the low rate of oxidation, Professor Long was unable to account.

On the question of the purification of the lower river, there was no uncertainty. To quote from Professor Long's remarks.

> The amount of albuminoid ammonia in the Illinois at Grafton is less than in the Mississippi at the same place, and the oxygen consumption is markedly less. The Illinois, at its mouth, is in better organic condition than are most of its tributaries. A larger flow would doubtless produce no very great change except in the oxidation of the free ammonia. The organic matter left here is probably mainly that derived from the soil, and much of this is of such a character as to undergo change but slowly. At Grafton little beyond the harmless salt remains to tell of the enormous pollution 320 miles above.

These remarks, it will be borne in mind, are based upon the investigations made during the time when the water of the Chicago river, contaminated with a great portion of the sewage of Chicago, was pumped into the sluggish Illinois and Michigan canal at Bridgeport, and flowed along the level to Lockport, receiving no dilution on the way.

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*Advance Notes of the Sanitary Investigations of the Illinois River and its Tributaries. Illinois State Board of Health. 1900.

†Chemical and Bacteriological Examinations of the Waters of the Illinois River and its Principal Tributaries by John H. Long, Sc. D., *infra*.

It has been stated that a great portion of the sewage of Chicago was carried into the Illinois river through the sluggish current of the Illinois and Michigan canal with but a small dilution of water, during the period covered by these preliminary investigations. More properly, however, should it have been stated that the greater portion of the sewage was thus conveyed. Professor Long estimated that from a population a little short of 2,000,000 the waste of 1,600,000 drained into the river. Professor Jordan* during the course of investigations made by him upon the Illinois river in 1899, at the request of the Director of Streams Examination for the Sanitary District of Chicago, observed that "the amount of sewage passing through the Illinois river by way of the Illinois and Michigan canal throughout this period (from May 1, 1899, to January 1, 1900,) is estimated to be as high as 85-90 per cent of the total sewage of Chicago."

As has been truly said, the acceptance, as a general proposition, of a view which is applicable to a particular case only, is illogical and may bring about disastrous results, hence it would hardly be proper to maintain that the results of the analyses made by the Illinois State Board of Health during 1886-89 and 1899, on the water courses leading from Lake Michigan to the Mississippi, unquestionably sustain the theory of self-purification of running streams. The diverse conditions obtaining in different waters, noted by Thresh, undoubtedly act as a controlling factor in some instances. There can be no doubt, however, that the results prove the fallacy of the saying that "no river is long enough to purify itself."

On the 17th day of January, 1900, nearly eleven years after the enactment of the "Sanitary District Act" and over seven subsequent to the inauguration of work on the channel, on the historic occasion known as "shovel day," the Chicago drainage and ship canal was formally opened and the course of the waters of the Chicago river and of those flowing from Lake Michigan became materially changed.

The work in connection with this channel, which has been termed the greatest feat of sanitary engineering in the world, is outlined in the following extracts from the act aforesaid:

An Act to Create Sanitary Districts and to Remove Obstructions in the DesPlaines and Illinois Rivers, and the Dams of Henry and Copperas Creeks, Approved May 29, 1889, in Force July 1, 1889.

Channel—How to be Constructed. § 23. If any channel is constructed under the provisions hereof by means of which any of the waters of Lake Michigan shall be caused to pass into the DesPlaines or Illinois rivers, such channel shall be constructed of a sufficient size and capacity to produce and maintain at all times a continuous flow of not less than 300,000 cubic feet of water per minute, and to be of a depth of not less than fourteen feet, and a current not exceeding three miles per hour, and if any portion of any such channel shall be cut through a territory with a rocky stratum where such rocky stratum is above grade sufficient to produce a depth of water from Lake Michigan of not less than eighteen feet, such portion of said channel shall have double the flowing capacity above provided for, and a width of not less than one hundred and sixty feet at the bottom, capable of producing a depth of not less than eighteen feet of water. If the population of the district draining into such channel shall at any time exceed 1,500,000, such channel shall be made and kept of such size and in such condition that it will produce and maintain at all times a continuous flow of not less than 20,000 cubic feet of water per minute for each 100,000 of population of such district, at a current of not more than three miles per hour, and if at any time the general government shall improve the DesPlaines or Illinois rivers, so that the same shall be capable of receiving a flow of 600,000 cubic feet of water per minute, or more, from said

* Some Observations on the Bacterial Self-purification of Streams, by Edward Oakes Jordan, Ph. D. (From the Bacteriological Laboratory of the University of Chicago.)

channel, and shall provide for the payment of all damages which any extra flow above 300,000 cubic feet of water per minute from such channel may cause to private property, so as to save harmless the said district from all liability therefrom, then such sanitary district shall, within one year thereafter, enlarge the entire channel leading into said DesPlaines or Illinois rivers from said district to a sufficient size and capacity to produce and maintain a continuous flow throughout the same of not less than 600,000 cubic feet of water per minute, with a current of not more than three miles per hour, and such channel shall be constructed upon such grade as to be capable of producing a depth of water not less than eighteen feet throughout said channel, and shall have a width of not less than one hundred and sixty feet at the bottom; in case a channel is constructed in the DesPlaines river, as contemplated in this section, it shall be carried down the slope between Lockport and Joliet to the pool, commonly known as the upper basin, of sufficient width and depth to carry off the water the channel shall bring down from above. The district constructing a channel to carry water from Lake Michigan of any amount authorized by this act, may correct, modify and remove obstructions in the DesPlaines and Illinois rivers wherever it shall be necessary so to do to prevent overflow or damage along said river, and shall remove the dams at Henry and Copperas Creek, in the Illinois river, before any water shall be turned into the said channel. And the canal commissioners, if they shall find at any time that an additional supply of water has been added to either of said rivers, by any drainage district or districts, to maintain a depth of not less than six feet from any dam owned by the State, to and into the first lock of the Illinois and Michigan canal at LaSalle, without the aid of any such dam, at low water, then it shall be the duty of said canal commissioners to cause such dam or dams to be removed. This act shall not be construed to authorize the injury or destruction of existing water-power rights.

Capacity of Channel or Outlet. § 20. Any channel or outlet constructed under the provisions of this act, which shall cause the discharge of sewage into or through any river or stream of water beyond or without the limits of the district constructing the same, shall be of sufficient size and capacity to produce a continuous flow of water of at least two hundred feet per minute for each one thousand of the population of the district drained thereby, and the same shall be kept and maintained of such size and in such condition that the water thereof shall be neither offensive or injurious to the health of any of the people of this State, and before any sewage shall be discharged into such channel or outlet all garbage, dead animals, and parts thereof, and other solids, shall be taken therefrom, *and said district shall at the time any sewage turned into or through any such channel or channels, turn into such channel or channels not less than 20,000 cubic feet of water per minute for every 100,000 inhabitants of said district, and shall thereafter maintain the flow of such quantity of water.

The investigations of the State Board of Health made since the opening of the main channel cover the time between the spring and end of the year 1900. The canal during this period did not carry continuously the full flow required by law, but the results obtained would not have been materially altered except possibly for the better, had a continuous flow of 300,000 cubic feet per minute been maintained during the time of the investigations. As noted by Prof. Long in reference to the experiments of 1899, conducted prior to the opening of the canal, "a larger flow would doubtless produce no great change except in the oxidation of the free ammonia."

So far as the connection between the sewage of Chicago and the flow of water in the canal is concerned, there can be but little appreciable difference between the effect of a flow, of 200,000 cubic feet per minute on the sewage of an estimated population of 1,600,000 and the effect of a flow of 300,000 cubic feet on the sewage of an estimated population of 2,000,000.

As has been demonstrated, however, not only in 1900, but also in 1899 the sewage of Chicago is by no means the most important factor in the pollution of the Illinois river.

In the investigations of 1900 the main results stated in the report of the investigations conducted in 1899 have been strengthened and confirmed.

Of the possible effect of the sewage of Chicago on the water of the Illinois river at its entrance into the Mississippi, the following remarks by Prof. Long will be found of remarkable interest: "I believe it may be safely said that if the whole of the sewage of Chicago were to be excluded from the Illinois river, the condition at Grafton

* As amended by Act of 1895.

would remain unchanged as far as organic contents and bacterial organisms are concerned. With the flow from Chicago excluded there would be a diminution in the harmless nitrates and chlorides only."

The recent analyses made by Dr. Long show that little purification takes place in the course of the Illinois and Michigan canal from Bridgeport to Joliet, but from that point the purification becomes very rapid. This was true not only during the summer of 1899, but also in 1900. Owing to the variation from day to day in the amount of sewage pumped at Bridgeport and also from time to time in the flow of the drainage canal during the year 1900, no comparison can be made from the analyses of sewage above Joliet for that period, but from Joliet to the Mississippi the conditions are unchanged except as to the volume of flow.

Comparison of Analyses of Illinois River Water in 1899 and 1900 Prior to and After the Opening of the Chicago Drainage Canal.

	Oxygen absorbed.		Chlorine.		Free. Ammonia.		Albuminoid Ammonia.	
	1899.	1900.	1899.	1900.	1899.	1900.	1899.	1900.
Joliet	25.69	6.97	85.49	31.40	16.05	4.66	2.88	0.85
Morris	9.16	6.40	61.80	17.80	10.09	2.84	1.20	0.63
Ottawa	7.13	5.94	57.40	17.20	6.23	0.81	C.62	0.39
LaSalle	6.99	5.60	41.30	15.80	4.66	0.55	0.58	0.36
Henry	7.00	5.86	43.20	16.90	3.28	0.41	0.55	0.40
Peoria, Narrows	6.86	5.05	33.04	15.50	0.89	0.21	0.57	0.34
Peoria, Wesley	17.44	9.91	34.97	16.60	4.36	1.62	3.20	1.34
Havana	7.18	6.46	29.17	15.00	1.69	0.41	0 69	0.41
Pearl	5.51	6.87	18.73	11.60	0.31	0.12	0.67	0 43
Grafton, Illinois	5.61	5:85	17.50	10.60	0.25	0.07	0.45	0.36
Grafton, Mississippi	8.52	11.73	1.77	2.00	0.08	0.07	0.44	0.54

The foregoing tabular statement has been prepared to show in parallel columns the results of the annalyses of the DesPlaines and Illinois river waters from Joliet to Grafton. As an indication of the organic matter, the oxygen absorbed shows a very great improvement in 1900. The chlorine contents of the water shows directly the effect of dilution, and the ammonias the effect not only of dillution; but of self-purification. Referring to this table in detail it will be noted that the amount of oxygen absorbed at Joliet in 1899 was 25.69 parts per million and in 1900, 6.97 parts per million. At Morris the oxygen absorbed in 1899 was 9.16 parts per million and in 1900, 6.40 parts per million. Between Joliet and Morris the DuPage and Kankakee rivers add their waters to that flowing past Joliet, and the dilution is represented by the chlorine constituents as shown in the table. In 1899 this dilution amounted to about 28 per cent and in 1900 about 45 per cent, thus showing that the large reduction of organic matter between Joliet and Morris in 1899 was due to purification and not dilution. Following down the river it will be observed that the condition of the water as shown by oxygen absorbed, chlorine, free ammonia and albuminoid ammonia continues to improve until LaSalle is reached. At LaSalle the Illinois and Michigan Canal enters the

Illinois river, and whatever sewage it contains at this point is discharged into the river. In addition to this the sewage of LaSalle and Peru, two cities having an aggregate population of 17,309 inhabitants, is added, and the oxygen absorbed and chlorine show slight increase at Henry, the first station below LaSalle. At the station below Peoria, called Wesley, the organic matter and chlorine are all increased, owing to the sewage received at Peoria. From this point the purification continues throughout the extent of the river.

There are some variations shown between the results of 1899 and 1900. The results of 1899 show a continual decrease of organic matter from Joliet to Peoria narrows and again from Wesley, just below Peoria, to the mouth of the river at Grafton, and the condition at Pearl and Grafton is better than above Peoria. On the other hand, in 1900 the condition of the river above Peoria is as good from the chemical and bacterial standpoint, if not better, than at Grafton. This is evidently due to the greater dilution of the Chicago sewage and may also be accounted for by a larger amount of sewage from Peoria and Pekin, as well as from the Sangamon river.

The report* of the bacteriologists which follows shows the same general conclusions as to purity of the water of the Illinois river as those drawn from the chemical analyses which have been referred to. Referring to the test of the water taken from the station just above Peoria, called The Narrows or Upper Peoria, the bacteriologists make this statement:

Direct intraperitoneal injection of water as well as a mixed 24 hour bouillon culture proved entirely non-virulent. Even large doses of a 24 hour culture at 37 degrees of one part of water and five parts bouillon could be given to Guinea pigs by intraperitoneal injection without causing death.

Bacterial self-purification is practically complete here and the Illinois river at this location contains less evidence of sewage pollution from the standpoint of qualitative bacteriological examination, that is, less pathogenic and sewage pollution, than at any other point between Lake Michigan and Grafton.

Referring again to the report of the bacteriologists regarding the pathogenic effect of samples of water and bouillon cultures made therefrom, we find the following statement:

Intraperitoneal injection of 4 c.c. of the different water samples proved non-pathogenic in all cases except Morris, LaSalle, Lower Peoria and Havana.

Bouillon cultures, 1.5, as per No. 8 above, caused *death promptly* in water samples from Western avenue, Bridgeport, LaSalle, Henry, Lower Peoria, Havana—Illinois river.

Uncertain Effect—Lake Michigan, Lockport, Joliet, Morris.

No Effect—Wilmington, Ottawa, Illinois and Fox rivers, Havana, Spoon river, Pearl, Grafton.

Bacterial purification begins at Joliet. Sewage bacteria decrease markedly at Morris and still more at Ottawa, where the bacteriological flora of the Illinois river and Fox river do not reveal great differences.

Pathogenic and sewage bacteria increase again at LaSalle and Henry.

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*Identification of Bacteria Found in Waters of the Illinois River and Its Principal Tributaries.—*Infra.*

The most marked bacterial purification occurs between Henry and Upper Peoria, where pathogenic and sewage bacteria are almost absent. Upper Peoria probably shows the least sewage pollution of any point between Chicago and Grafton.

At Lower Peoria we found a marked increase of pathogenic and sewage bacteria, similar to that of Joliet.

At Havana the conditions are worse and even anthrax, probably spores, were found here on two occasions.

At Pearl and Grafton much purification has again taken place, but some pathogenic and sewage bacteria are still present.

As a result of these studies, both chemical and bacterial, it is evident that the Illinois river is capable of purifying itself to a very marked degree. The organic evidences of the Chicago sewage as well as that introduced between Chicago and Peoria, have disappeared at Peoria, and we find the Illinois river at this point in as good a condition as the tributary streams. In our conclusions, however, we must not neglect to recognize the fact that the tributary streams are likewise more or less polluted with sewage, but none to the same extent as the Des Plaines and Illinois rivers. At Peoria and Pekin the introduction of organic matter is so great that even during the summer of 1900, when the low water flow was about 60 per cent more than that of former years, purification from this point to the mouth was no more complete than from Joliet to Peoria. Below Peoria dilution has very little effect on the purification of the waters of the Illinois, as the tributaries, except the Sangamon, furnish a comparatively small flow: and the Sangamon does not supply a pure water, but is not so much polluted as the Illinois.

The purity of the Illinois river at any point in its course will depend upon (1) the volume of water flowing, (2) the amount of sewage or organic matter introduced, and (3) the length of time which will elapse before such sewage shall reach the point in question, or, in other words, the distance above the point under consideration. It is not only possible, but more than likely that the waters of the Illinois above Peoria, although chemically and bacteriologically unobjectionable, have not as large a capacity, as it were, for purifying sewage as waters from Lake Michigan or other sources carying a larger amount of dissolved oxygen. If this condition be true at Peoria, it will also be true throughout the entire course of any stream which has once been excessively polluted. Hence, while any stream will, if given time enough, that is to say, length enough, practically purify itself after receiving a given amount of sewage, the fact still remains that the extent to which any stream may be expected to assimulate sewage and render it unobjectionable has difinite and fixed limits, which, if exceeded, will result in bringing about the nuisances and dangers which result from sewage. Just what amount of crude sewage any stream can receive without injury to its waters for domestic and manufacturing purposes depends upon the volume of stream flow, the distance to the point of use, and the rate of flow. A number of eminent sanitarians have undertaken to lay down rules to govern the practice of admitting sewage into streams based upon observation and experience, coupled with sanitary chemical and bacterial analyses.

This board determined from the analyses made by Professor Long in 1886-7-8 that about 17 volumes of Lake Michigan water to one volume of Chicago crude sewage would form a mixture which under the conditions of flow and distance would not become a nuisance or menace to the inhabitants of the Illinois river valley and the act creating the Sanitary District provides for 20 volumes of lake water to one volume of Chicago sewage or "20,000 cubic feet per second for each 100,000 inhabitants" of the Sanitary District.

It may be interesting to note the views of sanitarians on the effect of dilution of sewage, and as this subject has been considered at length by Rideal, the following statement in his recent treatise on Sewage* is given:

> With conditions that are favorable, the purifying action of rivers is known to be very great. Towns on the banks of rivers of considerable width, and having a fairly constant volume and velocity during all seasons have discharged their raw sewage into the stream for many years, and investigation has proved that a few miles below the outlet of the sewers there is little or no trace of pollution.
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> Many chemists believed that sedimentation was the main cause of any self-purification in river water. But any extensive improvement by mere sedimentation would be on the wrong lines, and should not be permitted, as it would result in a filling up of the river bed and formation of dirt banks which become foul. If, on the other hand, suspended organic matter is slowly removed to the river bed and there is attacked, in the absence of air and light, by the organisms naturally fitted to the purpose, their products will dissolve and become available for the water bacteria in the river.
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> Pettenkofer, * * * from investigations on the river Isar, at Munich, has concluded† that if the sewage never amounts to more than 1-15th, or 6.7 per cent of the river water, and the velocity of the latter is at least equal to that of the former, the raw sewage may be poured into the river without causing pollution.
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> In America, from the results of actual observations on rivers, under the direction of the Massachusetts Board of Health, Rudolph Hering fixes a limit to the amount of free ammonia permissible in a stream, and finds that if the flow of a stream is less than $2\frac{1}{2}$ cubic feet per second per 1,000 persons, or one gallon per minute per person, 'an offence is almost sure to arise' but when the flow is greater than 7 cubic feet per second per 1,000 persons then safety is assured. In other words, when the free ammonia is greater than 0.12 parts per 100,000, the conditions are probably objectionable. These limits correspond to about 50 volumes of river water to average sewage in this country. Mr. Stearns, the engineer to the Massachusetts board, concluded that if the average amounts to more than 1-40th, or 2.5 per cent of the river water, it can not be discharged into the river in its raw state; if it amounts to less than 1-40, and more than 1-130 it is doubtful; if less than 1-130 it may be admitted without any doubt in its raw state into the river. These conclusions are, of course, empirical, and have not been generally accepted; they would be greatly affected by the amount of solid matter present in the discharge. It must be remembered that the sewage in America is much more dilute than in this country, that the rivers have greater volume, and that the limit is much higher than we have found necessary in England.

In addition to the chemical analyses and bacteriological examinations above referred to the engineer of the board has made an extensive report upon the numbers and distribution of the inhabitants of the entire Illinois river drainage basin, monthly and annual rainfall

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*Sewerage and the Bacterical Purification of Sewage, by Samuel Rideal, D. S., London, England, 1900.

† Vide page xxii ante.

upon each tributary basin of the Illinois for 11 years—1890 to 1900—as well as a table of annual rainfalls at all stations in Illinois from the earliest records to date; original gaugings of the streams tributary to the Illinois and a series of gaugings to determine the flow of the Illinois river at all stages, at Peoria; also discharge tables and discussion of rainfall and run off for ten years—1890 to 1899. In addition to the foregoing data will be found statistics regarding the water supplies and sewerage of cities in the Illinois basin. These data lay the ground work for a thorough sanitary survey and oversight of the sanitary conditions existing throughout the State which will be followed up as thoroughly as funds available will permit.

These data regarding stream flow and rainfall are useful in considering the ultimate effect of the sewage from Chicago and other cities upon the Illinois river and its tributaries and for the first time make known the flow of the Illinois river at all stages.

It will be of interest to note that the entire population residing outside Chicago upon the Illinois river basin is about one and one-half millions, of which over six hunded thousand, forty per cent is classed as urban (living in cities and villages of 1,000 inhabitants or more) and the remainder rural. Of the urban population over three hundred and thirty thousand, or 55 per cent, live in cities of five thousand or more inhabitants. The population of the entire State according to the last U. S. census (1900) is 4,821,550, and the population of Chicago by the last census, 1,698,575. The increase in population of the State during the last decade was 26 per cent and of Chicago 54.4 per cent. The increase in population on the Illinois river basin was 10.3 per cent; the urban population increased 28.2 per cent and the rural population less than one per cent, or we may say, is substantially at a stand-still. This shows by actual count the generally recognized fact that the increase in population is in the cities and not in the country. With this increase of population centered in the cities, and especially in the great cities, the demands for improved sanitation increase in greater ratio than the increase in population.

The total population on the drainage area of the Illinois river, including Chicago, is about 3,200,000, or 67 per cent of the total population of the State of Illinois. Of this entire population about 600,000, or less than 20 per cent, is classed as rural. Taking this as a basis of comparison it will be seen that the Illinois river valley interests, as measured by the number of inhabitants, are primarily and largely with the cities.

The data on water supply and sewerage seem especially timely as pointing out the fact that a now large and ever increasing urban population is dependent upon surface waters for general and manufacturing uses. Mr. Harman's report brings out the fact that about half of the urban population not considering Chicago draws its water supply from streams and surface reservoirs which are now more or less subject to sewage contamination.

The streams of the State are the natural and necessary arteries of drainage, and while they must always receive the waste waters and

sewage, those wastes must be so prepared as to cause no damage, or if any, the least possible damage, to both public and private interests. One of the oldest established legal precedents is the right of the riparian owner to the enjoyment of the full flow of the stream in its natural condition, and to the end that such rights may be beneficial and useful he is entitled to the full use of the water of such stream subject to the condition that the water be returned at such place and in such condition as to give an equal right to all other riparian owners.

legal right to clean stream for use

As bearing on the subject of stream pollution the recent decision* of the Supreme Court of Wisconsin in the case of Mrs. Martha Winchell vs. the City of Waukesha, Wisconsin, (85 N. W. R. 668) is of vital interest, and because of the reasonable and comprehensive view which the court took in this matter such portion of the decision as explains that view will bear quoting here. The suit was brought against the city of Waukesha, by Mrs. Martha Winchell, who owns a farm on the Fox river, asking for an injunction against the further discharge of sewage into the river and for damages, on account of pollution, already suffered. The county court ordered the city to stop discharging its sewage into the stream and granted a jury trial to assess damages to the plaintiff. On April 9, 1901, the Supreme Court affirmed the decision with the modification that it might continue to discharge sewage into the river if the sewage "shall have first been so deodorized and purified as not to contain foul, offensive or noxious matter capable of injuring the plaintiff or her property or causing a nuisance thereto."

The following is a most important extract from the opinion of the court:

We can not but recognize that as the density of our population increases, as our citizens engage in new and greater industries, and as the municipal aggregations of population multiply and expand, the original purity of streams and water basins can not be wholly preserved. They are the natural and unavoidable courses and receptacles of drainage, through and into which must flow the refuse of human habitation and industry. How far these changing conditions must bring about a yielding of the private rights of continued purity of those lakes and streams to the necessity of use thereof for the public and general health and convenience, and upon what terms such yielding shall come, are primarily questions of policy for the Legislature, within the limits of its power over private rights defined by the constitution. When, if ever, the Legislature shall enact that streams generally or any streams shall be used as sewers without liability to the owners of the soil through which they run, the question of constitutional protection to private rights may be forced upon the courts for decision. Until such enactment is made, however, in clear and unambiguous terms, we shall be slow to hold by inference or implication that it has been made at all. The right of the riparian owner to the natural flow of water substantially unimpaired in volume and purity is one of great value and which the law nowhere has more persistently recognized and jealously

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*Vide also Morgan vs. City of Danbury (Conn.) 35 A. R. 500. Owens vs. City of Lancaster, (Pa.) 37 A. R. 858. Owens vs. City of Lancaster, (Pa.) 44 A. R. 559. Fisk vs. City of Hartford, (Conn.) 37 A. R. 983. Nolan vs. City of New Britain, (Conn.) 38 A. R. 703. Grey *ex rel* Simmons vs. Mayor, etc., City of Patterson, (N. J.) 42 A. R. 749. City of Valpariso vs. Hagen, (Ind.) 54 N. E. R. 1062. Platt vs. City of Waterbury, (Conn.) 45 A. R. 154. Mann vs. Wiley, (N. Y.) 64 N. Y. S. (S. C.) 589. City of San Antonio vs. Rivas, (Tex.) 57 S. W. R. 855. Com. vs. Yost, (Pa.) 46 A. R. 845. Weston Paper Co. vs. Pope, (Ind.) 57 N. E. R. 719.

protected than in Wisconsin. Not alone the strictly private right, but important public interests would be seriously jeopardized by promiscuous pollution of our streams and lakes.

Amid this conflict of important rights, we can not believe that the legislature concealed in words merely authorizing municipalities to raise and expend money for the construction of sewers a declaration of policy that each municipality might in its discretion, without liability to individuals, take practical possession of the nearest stream as a vehicle for the transportation of its sewage in crude and deleterious condition. The authority granted to municipalities is to construct sewers, but subject to the general legal restrictions resting upon such corporations forbidding invasion of private rights by creation of nuisance or otherwise. This view of the legislative purpose is enforced by the consideration that although liquid sewage must flow off along the general drainage courses of the vicinity, it is by no means physically necessary that it should carry with it the solids in an offensive or unhygienic condition. It is matter of common knowledge, and of proof in this case, that there are practicable methods for the decomposition and practical destruction of such solids before delivering them into open water courses; the most modern method, as explained in the evidence here, being treatment in septic bacteria tanks, whereby the decomposition and resolution into inoffensive and innocuous fluids, gases, and mineral solids is greatly expedited.

Now that the measures adopted by the city of Chicago to prevent its sewage from polluting the water supply of the city, by disposing of it in a manner apparently not prejudicial to the interests of the lives and health of the people of the Illinois valley, are essentially in operation, it is a serious question whether Chicago now has, or will have in the immediate future, access to a supply of water free from organic pollution. In the study of this problem there must be considered not only the deposit of tons of filth on the bottom of the lake for several miles distance from the city, the inevitable result of the emptying of sewage and dumping of dredgings and garbage into the lake during years past, but the contamination of the lake by municipalities on the immediate north and south.

The menace to the purity of the water supply occasioned by the former condition will lessen as time rolls by and ultimately disappear, but that arising from the existence of the latter must necessarily grow greater from year to year, unless wise counsel prevails and all interests both public and private, either jointly or severally, as may prove most expedient and economical, co-operate for the purpose of protecting the purity of the lake waters.

There is now under consideration a scheme of co-operation looking to the annexation of all the nearer suburbs of Chicago for the purpose of diverting the sewage to the main Drainage Canal and thus remove the immediate cause of further local pollution of Lake Michigan water in the vicinity of the Chicago water works intakes. The engineering and financial problems involved in these schemes are momentous and due consideration must be given to the main Drainage Canal, so that its capacity may not be exceeded even by the time the works for these new accessions shall be completed. The effect which the diversion of the great volume of diluting water may have on the level of the great lakes is being watched with jealous eyes by two governments, the United States and the Dominion of Canada, and from our neighbor state on the southwest, the city of St. Louis is protesting, even now, in the Supreme Court of the

Nation, against what she presumes to be a menace to the health of her people and a damage to her financial interests. The interests involved are so great and the problem so complex that every means which may be a substantial help to the solution of the problem of the preservation of the purity of the water supply and disposal of the sewage of Chicago must be given full weight and recognition.

The suggestions of Professor Long in his accompanying report regarding the possibility and practicability of removing largely the objectionable organic matter from sewage by bacterial treatment at the proper time and place is worthy of the most careful consideration. Much information upon the subject of bacterial purification of sewage is available from European as well as American experiments and experience, but the subject is so new that the possibilities are only beginning to be recognized.

Another condition said to constitute a possible danger, is shown by the experiments conducted by the United States Navigation Bureau in 1893-4, in order to determine the actual trend of the current of the great lakes. As regards Lake Michigan, the experiments clearly show that there is a rapid whirl at the south end with a strong current passing north along the east shore, while along the west shore the current flows south. The disposition of the currents, while favoring the water supply of Milwaukee, has a tendency, it is believed, to cause Chicago to receive in its water supply the contaminated water of Milwaukee. Whether this reported menace is fancied or real can not positively be asserted, but the importance which attaches to the effect of sewage on the great lakes will be appreciated from the fact that the United States Geological Survey has taken special pains to collect data upon this matter which has been published in "Water Supply and Irrigation Papers No. 22," in 1899. This report was prepared by Mr. George W. Rafter, C. E., who has had large experience in sanitary engineering matters. The following statement from this report sets out the situation very clearly:

According to statistics of the eleventh census, the basin of the Great Lakes, especially the area contiguous to Lakes Ontario, Erie, and Michigan, is, next to the Atlantic Seaboard, the most densely populated area of the United States. Bordering on Lakes Ontario, Erie, and Michigan are great and rapidly growing cities from which all of the sewage now passes into these lakes. The surrounding regions are usually not greatly elevated above the lakes, and hence do not afford any opportunity for obtaining upland waters for municipal supplies. The water supplies of towns on the Great Lakes are not only now almost universally taken from these bodies of water, but must necessarily continue to be so taken in the future. At present the sewage of the Great Lake cities is discharged without treatment into the same bodies of water from which the public water supplies are taken. An exception is the city of Rochester, which wisely brings its water supply by gravity from Hemlock, an inland lake about thirty miles distant; but Buffalo, Erie, Cleveland, Detroit, Chicago, Milwaukee, and many other towns take their water supplies in the manner stated. Without going into details for all the Great Lakes, we will state that Lake Michigan alone receives at the present time the sewage of municipalities and small towns aggregating over 2,000,000 people, and this population is rapidly increasing, having about doubled in ten years. A similar increase in population has taken place in the cities and towns tribu-

tary to the lower Great Lakes. Thus, Detroit had a population in 1880 of 116,340, and in 1890, 205,876. Cleveland showed a population in 1880 of 160,-146, and in 1890, 261,353. In 1880 Buffalo had 155,134; in 1890, 255,664.

On the same subject the following statement is also found in this report:

The modern studies all indicate that when organic matter in increasing quantities is continually poured into a body of fresh water, a point is quickly reached beyond which the body of fresh water, whether it be lake, pond, or running stream, has not power of further assimilation. Chemical analyses of the waters of the Great Lakes show a gradually increasing contamination during the last fifteen or twenty years. The evidence is multiplying that, with the present increase in population, the Great Lakes, if they continue to be used as common sewers, will soon become totally unfit for use as drinking water. When this time arrives, one of two alternatives must be followed—either every source of water supply must be filtered or the sewage of the towns must be efficiently purified before it is allowed to flow into the lakes. In some cases the conditions are such that both remedies must be applied.

Taking into consideration the many diverse and often conflicting interests and necessities of the rapidly increasing centers of urban population, which are involved in the procurement of abundant and wholesome water supplies for each, and the disposal of their sewage and garbage in a manner which will render them harmless and unobjectionable without becoming a financial burden beyond the reasonable ability of each city to bear, there is no possibility of avoiding the conclusion that the State of Illinois, and especially the upper Illinois river valley, has reached a stage of developement in population, manufacture, and commerce which calls for comprehensive study and State supervision of the sanitary conditions of public water supplies, and drainage and sewerage systems. Chicago and its nearby neighbors take their water supply from Lake Michigan, and many of the rapidly growing cities located on the Illinois river and its tributaries are dependent on these rivers for their water supplies. With increase of population more cities will be compelled to seek their water supplies from the streams because of limited ground water supplies, and the importance, even necessity, of maintaining the purity of those streams will be felt more and more from year to year.

The State of Massachusetts has taken a complete sanitary supervision of all public water supplies and sewerage systems, and New York and Ohio have followed her example. New Jersey has special laws against the pollution of its principal river, the Passaic, and Indiana has recently added new legislation against pollution of its streams.

The demand for State control of that portion of the public service which so vitally affects the health and lives of the people has been felt and recognized in those states by fitting legislation. It is the purpose of this Board to pursue its sanitary investigations and render such aid and advice to the municipalities of the State regarding water supply and sewerage as its means and opportunities will permit.

Springfield, May, 1901.

CHEMICAL AND BACTERIOLOGICAL EXAMINATION

OF THE

WATERS OF THE ILLINOIS RIVER

AND ITS

PRINCIPAL TRIBUTARIES

BY

JOHN H. LONG, Sc. D.

CHEMICAL AND BACTERIOLOGICAL EXAMINATION

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Waters of the Illinois River

AND ITS PRINCIPAL TRIBUTARIES

By John H. Long, Sc. D.

Dr. James A. Egan, Secretary of the Illinois State Board of Health:

Dear Sir:—In handing you the results obtained by the sanitary examinations of the waters of the Illinois river and its tributaries, authorized by your Board in June, 1899, I think it in place to make certain statements, by way of explanation and comparison, which follow in the pages below.

Since the earliest days of discussion on the question of an enlarged canal or waterway connecting Chicago with the Illinois river, much has been said and written about the probable effect of the sewage of the city of Chicago, if discharged by this canal, on the waters of the Illinois and Mississippi. The importance of such information as could be furnished by a study of the old Illinois and Michigan canal and the river into which it discharged, was recognized by former members of the Board, as it was constituted in 1880 to 1890, and by the authority of the Board I undertook an extended investigation of the problem in 1886, 1887, 1888 and 1889, most of the work being done between May, 1888 and March, 1889. In all, about 700 samples of water were taken from points along the canal, the Illinois river and the Mississippi river. The results of the analyses of these waters were embraced in a preliminary report made to the Board in March, 1889. This report was printed in pamphlet form, and very hurriedly, to meet an emergency. The full report which I submitted some months later contained much matter not in the hastily written preliminary notes, but it was never published. Through changes in the Board it appears that it was misplaced and finally lost.

In these investigations two facts were brought out prominently: First, that there is a marked improvement in the water of the Illinois as it flows toward the Mississippi, and this quite independent of changes by sedimentation or dilution; and second, that the rate of change is largely dependent on temperature, the winter rate being much slower than the summer rate.

Since then the great Drainage Canal was begun and has been completed, and we are again confronted with the question, what will be its effect on the water of the lower river? To answer this question in a satisfactory manner it was considered desirable to make two new

series of investigations, bacterial as well as chemical, and the main results of these will be given in the following pages. Before beginning the actual examinations a trip of inspection was undertaken by the engineer of the Board, Mr. Jacob A. Harman, and myself. In this we followed the length of the river and canal from Bridgeport to Grafton, in a small boat, which made it possible to observe the whole course thoroughly and note all points of interest. The practical information obtained from fishermen and others constantly employed on the river must be given due weight in any final conclusion reached regarding the character of the water in the lower river.

It is a fact not generally known that there is an important fishing industry at many points on the river, beginning with Peoria and ending with Grafton. Fine fish are caught in the river in quantity, just above Peoria, and these find a ready sale, not only in the local market but in other cities. The river is temporarily fouled by the ordinary sewage and cattle-shed waste of Peoria and Pekin, but above Havana the stream again becomes the home of clean fish. From this point down the fishing industry assumes greater importance, and in the early season a large part of the catch finds sale in the eastern markets. It is well known that such fish can not live in filthy water; they are not found in the upper river and their appearance below is evidence of the gradual changes wrought by dilution and oxidation. It is also worthy of note that this industry has increased rather than declined in the last ten years.

The first series of investigations were made in the river before the opening of the drainage canal and the second series at about the same season of the year, after the increased flow of water was turned on from Lake Michigan. Both series were sufficiently extended to cover the effects due to variations in temperature, as will be seen from the dates in the tables below.

POINTS OF COLLECTION.

The preliminary survey led to the selection of the following places as points of collection for the examinations made before the opening of the large canal:

1. *Bridgeport (Chicago)*—Illinois and Michigan canal. Samples were taken from under the bridge, at the beginning of the canal, just west of the pumping station, by some one sent from my laboratory.

2. *Lockport*—Illinois and Michigan canal. Samples were taken from a point 200 feet east of the main bridge and above the entrance of a small stream.

3. *Lockport*—Des Plaines river. The water for examination was taken above the stone bridge, north of town. Mr. P. O'Brien made both collections.

4. *Joliet*—Mixed canal and Des Plaines water. Collections were made by Mr. B. F. Long at a point in the upper basin, away from construction work.

5. *Wilmington*—Kankakee river water. Samples were taken by Mr. C. D. Cassingham from near the middle of the river, just below the town.

6. *Morris*—Illinois river. Collections were made by Dr. H. M. Ferguson from the middle of the stream, just above the wagon bridge.

7. *Ottawa*—Illinois river. Collections were made by Dr. W. A. Pike, from a point in the river about 600 feet above the mouth of the Fox river.

8. *Ottawa*—Fox river. The samples were taken by Dr. Pike, at first from a point about 300 feet above the Rock Island bridge, but later, on account of low water, from the canal feeder, as this carries most of the Fox water in dry weather.

9. *LaSalle*—Illinois river. The samples were taken from the center of the stream, by Mr. C. H. Nicolet, at a point 600 feet above the mouth of the Big Vermilion.

10. *LaSalle*—Big Vermilion river. Collections were made by Mr. Nicolet, and from a point in the stream about 600 feet above its junction with the Illinois.

11. *Henry*—Illinois river. Collections were made by Mr. H. J. Gregory from the middle of the river, 600 feet above the dam.

12. *Peoria*—Illinois river. Two sets of samples were taken here—the first at the "Narrows," near the Peoria water works, and about 100 yards above the wagon bridge, by Mr. C. F. Hixson.

13. *Peoria*—Illinois river. The second set of samples were taken by Mr. Henry Ocker, about two miles below the city and one-half mile below Wesley.

14. *Pekin*—Illinois river. The station chosen was about two miles below the Pekin bridge and 600 feet below the last manure trough from distillery barn. Samples were taken by Mr. D. H. Jansen.

15. *Havana*—Illinois river. The first two samples were taken 200 yards above the wagon bridge and near the center of the stream. After that they were taken above the mouth of the Spoon river. Mr. S. F. Kyle made the collections.

16. *Havana*—Spoon river. Samples were collected from this stream by Mr. Kyle, and at a point several hundred feet above its mouth.

17. *Browning*—Sangamon river. This stream enters the Illinois opposite the town of Browning. Samples were taken by Mr. G. P. Hollingsworth, 600 feet above the mouth of the river.

18. *Pearl*—Illinois river. The collections were made about 200 feet below the Alton bridge, from the middle of the river, by Mr. E. H. Chandler.

19. *Grafton*—Illinois river. The point of collection chosen was about a mile and a half above the town and beyond the influence of the Mississippi. Mr. F. M. Calhoun was the collector.

20. *Grafton*—Mississippi river. A number of samples were taken from the center of the main channel, opposite the government light on the point of the island north of Grafton. These also were taken by Mr. Calhoun.

After the drainage canal was opened, samples were taken for the second series of tests at the same points in the main, but water was taken also from the new canal at Western Avenue bridge and from the basin of the controlling works at Lockport. The Joliet station was changed to a point below the lower bridge but above the sewer outfalls.

HEAD WATER SAMPLES.

As having a bearing on the question of the nature of the diluting waters entering the Illinois a number of samples were taken from points as near as possible to the head waters of the most important of the tributaries. In this connection several analyses of Lake Michigan water were made, the samples being taken from a faucet in

the basement of the Northwestern University laboratory building, 2421 Dearborn street, Chicago. This water comes mainly from the four-mile tunnel through the Fourteenth street pumping station; during the recent investigations frequent tests were made of this lake water.

Samples of Upper Kankakee water were taken by Dr. George W. Van Benschoten from a place in the river near South Bend, Indiana.

Upper DesPlaines water was taken near Libertyville, by Mr. Clare Sherman.

Upper DuPage samples were taken near Wheaton, by Dr. C. F. Blanchard.

Upper Fox river samples were taken by Dr. Charles H. Fegers, at McHenry.

Upper Big Vermilion water was collected by Dr. J. J. Stites, at Pontiac.

Mackinaw river water was taken by Dr. R. E. McKenzie, at Kappa.

Upper Sangamon water was collected by Dr. John H. Gardiner, at Mahomet.

Upper Spoon river water was collected at Dahinda, by Dr. J. B. Bedford.

In all cases explicit directions were given to the gentlemen who made the collections as to the proper manner of taking and forwarding the samples. Boxes containing two bottles were sent by express to each collector in time to make the weekly collections. A large glass-stoppered bottle holding one gallon was used for the water intended for the chemical analysis, and a six ounce bottle, with glass stopper, was used for the water employed in the bacterial tests. Both bottles were thoroughly cleaned before being sent from the laboratory, and the small one, in addition, was sterilized by steam. So far as possible the method of collecting the samples was explained to each collector through a practical illustration, the first collections being in most cases made by myself, in the presence of the collector. When it was not possible to give this kind of an illustration, very lengthy directions were sent by mail. In addition to this each collector was furnished with a card for each collection, bearing on one side the following directions:

DIRECTIONS FOR COLLECTING AND SHIPPING WATER.

Samples are to be collected at times given on accompanying card until further notice. Remove stopper from large bottle and fill it by holding the neck about one foot below the surface of the stream. When the stopper is inserted the bottle should not be absolutely full, but an air space of about one inch left for expansion. Tie the stopper down securely and place the bottle in the proper compartment of the shipping box. The bottles are clean when sent from the laboratory to the collector. The small bottle is for the water for bacterial examination and must be carefully handled. It is sterilized before being sent from the laboratory. Before collecting sample, which must be done at the same time and place as the gallon sample, have ready several pounds of broken ice to pack around bottle, as to be explained. When ready to make the collection, not before, take the small bottle from the can, loosen the rubber band around the neck of the bottle and, without

removing the rubber cloth, partly withdraw the stopper from the neck. Now, using both hands, plunge the bottle below the surface of the water and allow it to nearly fill. Then insert the stopper, twist it well in and fasten it down by rubber band. Put the bottle in the small can and pack around with cotton. Then put the small can in the large one and pack the space with broken ice and excelsior. The large can in turn is put in its compartment in the box and packed with excelsior. Ship without delay to

J. H. LONG, 2421 Dearborn street, Chicago.

Fill out the blank on the other side. Enclose in shipping envelope.)

On the other side these directions were printed:

ILLINOIS STATE BOARD OF HEALTH.

EXAMINATIONS OF WATER.

Place of collection.................Date of collection......................

Name of collector...

Temperature of water..............Temperature of air......................

Remarks:

(Under remarks record anything unusual in appearance of water, or anything regarding rainfall or storms.

As a rule the directions were carefully followed, and most of the samples came to the laboratory in good condition. Much here depended on the directness of the railroad and express connections. It was interesting to note that from the station the most remote from Chicago, and in many respects the most important, Grafton, the water for the bacterial tests was always cold, except once, much ice still remaining around the can containing the small bottle.

The number of samples sent from each place, between July and December, 1899, is given in the following table:

Chicago, Lake Michigan	5	Havana, Illinois	18
Bridgeport, Canal	21	Havana, Spoon	4
Lockport, Canal	22	Browning, Sangamon	7
Lockport, DesPlaines	7	Pearl, Illinois	18
Joliet, Canal and DesPlaines	17	Grafton, Illinois	21
Wilmington, Kankakee	9	Grafton, Mississippi	13
Morris, Illinois	22	South Bend, Kankakee	3
Ottawa, Illinois	22	Libertyville, DesPlaines	4
Ottawa, Fox	6	Wheaton, DuPage	3
LaSalle, Illinois	21	McHenry, Fox	3
LaSalle, Big Vermilion	8	Pontiac, Big Vermilion	3
Henry, Illinois	19	Dabinda, Spoon	3
Peoria, Narrows, Illinois	15	Kappa, Mackinaw	2
Peoria, Wesley, Illinois	21	Mahomet, Sangamon	3
Pekin, Illinois	19		

During the spring of 1900, February, March and April, collections were made as follows:

Chicago, Lake Michigan	10	Havana, Illinois	9
Bridgeport, I & M. Canal	1	Havana, Spoon	7
Western avenue, Drainage Canal	7	Pearl, Illinois	8
Morris, Illinois	8	Grafton, Illinois	11
Peoria, Wesley	8		

In the summer and autumn of 1900 these collections were made:

Chicago, Lake Michigan	14	Peoria, Narrows, Illinois	13
Bridgeport, I. & M. Canal	15	Peoria, Wesley, Illinois	16
Western avenue, Drainage Canal	14	Pekin, Illinois	15
Lockport, basin	11	Havana, Illinois	15
Joliet, mixed water	15	Havana, Spoon	4
Morris, Illinois	15	Pearl, Illinois	14
Ottawa, Illinois	15	Grafton, Illinois	17
Ottawa, Fox	3	Grafton, Mississippi	6
LaSalle, Illinois	15	Browning, Sangamon	3
LaSalle, Big Vermilion	3	Wilmington, Kankakee	3
Henry, Illinois	15		

METHODS OF ANALYSIS.

On reaching the laboratory the waters were submitted to analysis without delay, as this is a matter of prime importance as far as some of the chemical tests are concerned, and a practical necessity in the case of the bacterial examinations. The following data were determined:

Solids in solution,
Total solids,
Chlorine,
Oxygen consumption in original water,
Oxygen consumption in filtered water,
Free ammonia,
Albuminoid ammonia,
Nitrogen in nitrites,
Nitrogen in nitrates,
Total organic nitrogen in some cases,
Loss on ignition in some cases.

In the bacterial examination a count of the number of colonies grown on slightly alkaline gelatin was made in the usual manner. A fermentation test with sugar bouillon, using two or three dilutions, the reaction for indol, and the coagulating action on milk were also tried. In addition to these routine tests a large number of pure cultures were made on gelatin or agar for identification and comparison of species, and the pathogenic or non-pathogenic character of many of these were found by experiments on animals. The latter work has all been carried out by or under the direction of Professor Gustav Fütterer, of the Northwestern University, who will make his determinations the subject of a special report.

A brief discussion of the methods followed in the chemical examinations will not be out of place:

1. The solids in solution were found always by evaporating 250 or 500 cc of carefully filtered water to dryness in platinum on a large water bath. The residue was heated to 110 deg. C, for half an hour, before weighing. In the filtration, a fine, thoroughly washed Swedish filter paper was used. Before evaporation 5 milligrams of pure sodium carbonate was always added and the final result diminished by this amount.

2. The total solids were found in the same manner by evaporation of unfiltered water. The difference gives the weight of solids in suspension.

3. In a few cases the chlorine was found by direct titration of the water by the Volhard process. But generally it was found preferable to concen-

trate a half liter or more, after addition of a little pure sodium carbonate, to a very small volume, and use the residue for the Volhard titration. This is much better than the usual method of direct titration of 100 cc or less, with use of chromate as indicator. The results by this latter common process are almost invariably too high, as shown by data published concerning the amount of chlorine in Lake Michigan, and in some of our pure river waters. The results of the Volhard process are much nearer the truth.

4. In determining the oxygen consumption I employ the acid Kubel process. This consists in adding to 100 cc of the water 5 cc of dilute sulphuric acid, 1 volume to 4, then a measured excess of one-hundredth normal permanganate solution, usually 10 cc. The mixture is boiled five minutes and decolorized by addition of one-hundredth normal oxalic acid. Finally, more permanganate is added to distinct coloration and the excess of this required beyond that used by the oxalic acid is considered as consumed by the organic or other reducing matters in the water. The amount of permanganate required by waters holding much organic matter in suspension is often greatly in excess of that required by the filtered water, which is a measure of the organic matter in actual solution. Two tests were therefore made, one on the water as received, and the other after filtration. For the filtration a well washed Swedish paper must be used. Some of the ordinary papers give up enough reducing matter to materially influence the results.

5. Free ammonia was found by the usual process of distillation after the addition of a little pure sodium carbonate. In most cases 500 cc was the volume taken for distillation, but in the highly contaminated waters 25 to 250 cc was taken and diluted with ammonia-free water before distillation. Five portions of 50 cc each were distilled and Nesslerized separately.

6. The 250 cc left in the retort after the distillation of free ammonia is used for albuminoid ammonia. It is treated with 50 cc of a strong alkaline permanganate solution and distilled again, four portions of 50 cc each being saved. These are Nesslerized as before. The permanganate solution used was made by dissolving 20 grams of good potassium permanganate in one liter of water by aid of heat. The solution was mixed with one made by dissolving 450 grams of potassium hydroxide in about a liter of water. The mixture was diluted to about 2,500 cc with pure water, and then boiled down to 2,000 cc, cooled and bottled. This procedure furnishes an active permanganate of high oxidizing power.

7. The nitrite test is made on the water as soon as received by the well-known method with sulphanilic acid and napthylamin hydrochlorate. The reagents are made by dissolving a gram of each substance in 200 cc of 25 per cent acetic acid. 100 cc of the water under examination is mixed with 2 cc of each reagent and the color developed (if any) is compared with that from a standard solution of sodium nitrite, similarly treated. The sodium nitrite solution is best made from the pure commercial salt, instead of from silver nitrite by double decomposition. Nitrite can be bought which shows by analysis 95 to 98 per cent. A good dry preparation may be analyzed once for all and kept in a well stoppered bottle as a standard.

8. In the nitrate test we have the choice of several methods, but in the present work I have employed the phenol-sulphonic acid process. The reagent is made by heating 30 grams of pure phenol with 200 cc of the purest obtainable strong sulphuric acid in a flask immersed in boiling water for six hours. This is to insure the production of the disulphonic acid, instead of the mono product, formed at a lower temperature, the former acting readily on the nitrate to yield picric acid. In most of the waters 10 to 25 cc was usually evaporated in porcelain on the water bath, just to dryness. 1 cc of the reagent is added and mixed well with the residue, then some water, and finally an excess of ammonia to make 50 cc in all. The color developed (if any) is compared with that of a standard picric acid solution made from a known amount of potassium nitrate under similar conditions.

9. The total organic nitrogen was found in a few samples by evaporation of the water to expel free ammonia and treatment by the Kjeldahl process. 250 or 500 cc was boiled down in a flask to drive off free ammonia. Strong sulphuric acid was then added and the mixture concentrated and heated to

complete destruction of the organic matter. The residue was diluted, made alkaline with an excess of pure sodium hydroxide and distilled. 250 cc of distillate was collected and Nesslerized in the usual manner. The nitrogen is calculated from the ammonia found. The Kjeldahl ammonia is usually between three and four times the albuminoid ammonia.

10. In all of the investigations of the second series the loss on ignition was found. This was done by igniting the evaporation residues, dried at 110 degrees C, to destroy organic matter and leave a white ash. The residue was moistened with ammonium carbonate solution, dried again, gently heated, cooled and weighed. The difference between this weight and the first is the loss on ignition.

The methods of analysis outlined are all standard methods, and they have been slightly modified only when experience suggested the possibility of securing greater accuracy. I have been very ably assisted in the work by Mr. Frank Wright and Mr. William Johnson, and in some of the bacterial manipulations by Mr. Charles Erickson, also. I give in tabular form below the numerical results obtained by the various tests. The individual results are very irregular, but the averages as given show the general condition of the river throughout the period under consideration. The causes of some of the apparent irregularities and discrepancies will be pointed out in the discussion below. The first set of tables show the results obtained before the opening of the main drainage canal, and following there will be given the data for the later work carried out in 1900.

TABLE I.—*Chicago—Lake Michigan—*

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water.....	Air.........	In solution.	In suspension......	Total......	Not filtered	Filtered...
1899.											
July	17	None	None........	None........	......	......	......	......	144	1.12	1.12
··	31	··	··	··	......	......	160	......	160	1.12	1.12
Aug.	14	··	Good........	··	......	......	132	......	132	1.20	1.20
Nov.	4	None, nearly clear	··	Little	......	......	134	8	142	0.88	0.88
··	27	None, nearly clear	None........	None........	......	......	140	......	140	0.96	0.96
		Averages...	....	....	......	......	142	2	144	1.05	1.05

TABLE II.—*Bridgeport—*

1899.											
July	1	....	Oily.........	Black	......	......	......	......	578	39.2	......
··	17	....	Bad	··	......	......	596	92	688	31.6	20.8
··	24	....	··	··	......	......	476	72	548	31.2	20.8
··	31	....	··	Some........	......	......	476	64	540	25.2	10.4
Aug.	7	Dark, milky....	··	Little	......	......	404	56	460	22.7	16.3
··	14	Very turbid....	··	Dark.........	......	......	504	64	568	25.6	13 2
··	21	Dark, milky....	··	Black	......	......	500	56	556	19.2	10.7
··	28	··	··	··	......	......	484	48	532	29.1	20.2
Sept.	4	Dark	··	··	......	......	460	68	528	24.0	17.6
··	11	··	··	··	......	......	558	104	662	34.2	20.2
··	18	Bluish black...	··	Little	......	......	472	44	516	34.6	22.0
··	25	Dark, turbid...	··	Black	......	......	404	36	440	29.4	22.4
Oct.	2	Dark	··	Dark.........	......	......	488	20	508	28.5	21.4
··	10	Dark, turbid...	··	None.........	......	......	508	20	528	20.2	15.0
··	16	·· ...	··	Little	......	......	424	42	466	22.7	16.7
··	23	·· ...	··	··	......	......	416	56	472	16.9	14.4
··	30	·· ...	··	Black	......	......	470	56	526	28.5	16.3
Nov.	6	·· ...	··	Dark.........	......	......	446	54	500	21.1	13.1
··	13	Dark	··	Black	......	......	492	80	572	26.6	16.3
··	20	··	··	Dark.........	......	......	468	172	640	28.8	17.0
··	27	Dark, turbid...	··	··	......	......	414	66	480	20.5	10.2
		Averages...	....	....	......	......	473	63.5	536.5	26.65	15.95

City Water from Tap.

Chlorine..........	Ammonia		Nitrogen.		Colonies—per cc	Fermentation.			Coagulation of Milk.	Indol produced?....
	Free	Albuminoid	In nitrates.	In nitrites..		1-10cc. (Per cent).....	1 cc. (Per cent).....	1 cc. (Per cent).....		
2.13	0.132	0.104	Trace..	None..	....	....	None..	None..	Very slow..........	No.....
2.13	0.026	0.094	None..	Trace..	240	....	"	"	"	" ....
1.42	0.036	0.098	"	"	2,112	....	"	"	Slow...............	" ....
1.42	0.032	0.10	"	None..	37	....	"	"	Extremely slow....	" ....
1.77	0.026	0.12	"	"	58	....	"	"	"	" ....
1.77	0.050	0.103								

Pumping Station.

105.3	18.0	3.4	None..	None..	*75,600	....	60	60	Rapid	Yes....
81 7	11.5	4	"	0.64	*126,720	....	5	60	Very rapid.........	" ....
78.01	15.0	3.5	"	None..	1,015,000	....	10	10	"	No.....
85.2	13.7	4.8	"	Trace..	840,000	....	40	30	Rapid	" ....
78.1	13.2	8.7	"	"	980,000	....	55	55	6 hours.............	" ....
117.1	29.0	2.1	"	None..	594,000	....	60	50	"	" ....
120.7	20.5	1.6	"	"	1,360,000	....	40	10	Rapid	" ....
113.6	21.0	2.1	"	"	2,125,000	10	70	....	Very rapid.........	" ....
124.3	22 5	2.9	"	Trace..	2,110,000	....	50	40	6 hours.............	Yes....
142.0	27.1	2.2	"	"	63,000	30	30	....	12 hours............	" ....
103.0	21 5	2.5	"	0.01	517,000	30	40	....	Rapid	" ....
60.4	17.5	1.4	"	None..	244,800	10	50	....	"	" ....
96.0	27.7	5.9	"	"	795,600	40	50	....	"	" ....
85.2	19.5	2.7	"	"	1,468,800	30	20	....	Very rapid.........	" ....
85.0	26.2	4.0	"	"	503,200	20	25	....	Rapid	" ....
81.7	19.7	2.2	"	"	161,200	40	50	....	Very rapid.........	" ....
81.7	18.3	2.6	"	Trace..	887,000	60	45	....	"	" ....
89.0	17.3	2.9	"	0.01	1,330,000	60	40	....	"	" ....
113.6	21 2	4.1	"	None..	2,982,000	20	30	....	Rapid	" ....
85.2	20.0	4.7	"	"	931,500	10	50	....	Very rapid.........	" ....
78.1	16.3	4.4	"	"	594,000	25	50	....	"	" ....
95.47	19.94	3.22		0.03						

*Acid medium.

TABLE III.—*Lockport*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water......	Air......	In solution.	In suspension......	Total......	Not filtered	Filtered....
1899.											
July	3	Dark	Bad	Heavy.......	......	......	......	......	584	31.20	......
″	10	....	″	Black	......	......	......	......	572	31.60	......
″	17	....	″	″	71.6°	80°	560	52	612	15.20	8.80
″	24	Dark	″	″	......	......	528	128	656	25.92	14.56
″	31	″	″	″	......	......	476	80	556	27.52	14.24
*Aug.	7	″	″	″	69.8	80	512	56	568	29.12	22.40
″	14	Black..........	″	″	68.0	78	544	20	564	29.44	16.48
″	21	Very dark......	″	″	72.5	84	472	52	524	26.56	17.60
″	28	″	″	″	75.2	85	512	68	580	30.08	21.76
Sept.	4	Dark	″	″	73.0	84	424	56	480	24.96	15.36
″	11	Very dark......	″	″	64.0	78	498	78	576	32.00	22.72
″	18	Dark	″	″	68.0	70	448	56	504	29.44	19.20
† ″	25	″	″	″	60.0	68	528	64	592	32.64	22.08
Oct.	2	″	″	″	52.0	75	480	56	536	21.76	12.16
″	9	Very dark......	″	″	68.0	70	428	60	488	20.48	15.68
″	16	Dark	″	″	66.0	76	436	64	500	24.48	14.40
″	23	″	″	″	64.0	74	458	64	522	27.52	18.40
″	30	″	″	″	54.0	64	494	78	572	29.12	16.32
Nov.	6	″	″	″	55.0	65	518	64	582	30.22	19.20
″	13	″	″	″	50.0	60	476	64	540	25.60	17.92
″	20	Very dark......	″	″	54.0	65	530	94	624	37.76	19.84
″	29	Dark	″	″	50.0	65	500	84	584	31.36	17.12
		Averages...	....	....	......	......	491	67	558	27.90	17.31

* Bacterial sample warm.

† Bacterial sample taken from large bottle. Other broken.

TABLE IV.—*Lockport*—

1899.											
July	3	....	Good	Some........	......	......	......	......	452	10.18	......
″	17	Turbid.........	″	″	75°	80°	248	20	268	11.20	9.76
″	31	Light, turbid ..	″	Little........	......	......	376	8	384	8.00	7.12
*Aug.	14	Light	Earthy......	″	......	......	324	12	336	7.36	6.80
″	28	Light, clear....	″	None........	77	85	360	12	372	7.92	7.28
Nov.	6	″	Little,.......	Sandy	48	65	452	40	492	6.48	5.54
″	20	″	Good	None........	52	65	480	4	484	5.36	5.36
		Averages ..	....	....	......	......	373	16	389	8.05	6.96

* Bacterial sample warm.

Canal.

Chlorine..........	Ammonia. Free......	Ammonia. Albuminoid	Nitrogen. In nitrates.	Nitrogen. In nitrites..	Colonies—per cc....	Fermentation. 1-10 cc. (Per cent....	Fermentation. 1 cc. (Per cent....	Fermentation. 1 cc. (Per cent....	Coagulation of Milk.	Indol produced?....
76.3	20.6	1.8	None..	None..	212,000	....	65	65	Rapid	Yes....
95.85	21.0	6.0	"	"	64,320	10	10	None..	....	No.....
74.5	8.5	1.5	0.70	0.64	247,400	....	50	....	12 hours............	" ....
92.3	19.2	3.5	None..	None..	395,000	....	None..	None..	"	" ....
92.3	14.5	3.4	"	"	375,000	....	15	15	Rapid	" ....
113.6	21.0	2.4	"	"	385,000	....	50	....	12 hours............	" ....
110.0	19.0	2.9	"	"	726,000	....	60	90	Rapid	" ....
92.3	10.10	4.9	"	"	560,000	....	60	60	"	" ....
113.6	16.8	3.4	"	"	1,750,000	5	40	....	"	" ....
81.7	19.7	1.9	"	"	147,500	30	50	....	Very rapid.........	Yes....
110.0	26.8	2.4	"	"	896,000	20	10	....	"	" ....
88.8	18.5	1.1	"	"	84,200	40	50	....	"	" ....
110.0	20.3	1.1	"	"	38,400	25	25	....	Rapid	" ....
103.0	23.5	5.7	"	0.02	315,000	20	20	....	"	" ....
71.0	16.5	3.9	"	Trace.	330,000	20	60	....	"	" ....
86.6	25.6	3.6	"	None	334,800	35	40	....	"	" ....
96.0	23.0	2.6	"	0.02	285,000	20	50	....	Very rapid.........	" ....
103.0	25.0	4.1	"	0.01	161,200	40	40	....	"	" ....
103.0	20.0	5.0	"	None..	533,200	50	50	....	Rapid	" ....
95.9	19.5	3.8	"	"	621,000	15	20	....	"	" ....
113.6	22.3	4.2	"	"	714,000	30	25	......	"	" ....
110.0	25.5	5.0	"	"	432,060	10	10	....	"	No.....
96.97	19.85	3.37	0.03	0.03						

The DesPlaines River.

4.26	0.70	0.90	None..	None..	108,900	....	None..	None..	Slow................	No.....
3.55	0.35	0.68	0.32	0.05	....	....	"	"	24 hours............	" ....
4.97	0.12	0.418	None..	None..	44,200	....	10	5	Slow................	" ....
5.68	0.15	0.498	"	0.004	99,000	....	None..	None..	"	" ....
7.10	0.126	0.468	"	Trace .	59,400	....	"	"	"	....
2.84	0.114	0.55	"	0.01	29,200	None..	"	....	"	No.....
13.50	0.042	0.40	"	Trace .	700	25	20	....	Very slow..........	" ....
5.98	0.229	0.559	0.045	0.009						

TABLE V.—*Joliet*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered
1899.											
July	3	Dark	Bad	Yellow	......	......	......	......	580	20.00	......
"	17	"	"	Black	76°	90°	384	140	524	20.32	12.96
"	24	"	Bad, oily	"	78	85	496	48	544	17.76	10.56
Aug.	1	"	"	"	74	76	500	124	624	23.04	14.72
"	7	"	"	"	72	84	536	16	552	27.52	19.84
"	14	"	"	"	70	80	496	32	528	17.76	14.40
"	21	Dark, turbid	"	Some	82	88	476	40	516	16.00	11.52
"	28	Very dark	"	Heavy	78	86	528	332	860	40.32	18.24
Sept.	4	Dark	"	"	80	86	448	56	504	21.76	15.04
"	11	"	"	Heavy black	......	......	508	148	656	32.96	19.84
* "	18	"	"	Black	60	70	508	52	560	27.84	19.52
† "	27	"	"	"	62	54	496	160	656	35.84	19.20
Oct.	2	Very dark	"	"	61	58	520	144	664	31 68	15.36
"	9	Dark	"	"	60	68	474	136	610	27.85	15.68
‡ "	16	Dark, turbid	"	Heavy black	64	58	440	64	504	21.76	13.12
"	23	Very dark	"	Black	64	68	468	100	568	28.48	18.56
Nov.	6	Dark	"	"	52	46	512	74	586	25 92	18.24
		Averages	....	....	......	......	487	104	591	25.69	15.10

* Collected 12 hours after a rain.

† Collected 24 hours after a rain.

‡ Rain at time of collection.

TABLE VI.—*Wilmington*—

1899.											
July	19	....	....	....	82°	86°	388	20	408	4.64	4.16
Aug.	2	Turbid	Good	Little	80	86	280	52	332	7 36	6.48
"	16	Light	"	"	78	84	276	52	328	7.04	5.52
"	30	Dark	"	Brown	82	90	260	78	338	5.92	5.84
Sept.	13	Light, turbid	"	Little	68	70	248	40	288	6.68	6.56
"	26	"	"	Sandy	58	68	258	22	280	5.28	4.96
Oct.	11	"	None	Very light	60	67	260	30	290	4.24	3.52
"	25	Light yellow	Good	Light	62	76	250	38	288	4.72	3.68
Nov.	15	"	None	None	52	47	348	......	348	5.36	5.12
		Averages	....	....	......	......	285	37	322	5.71	5.09

Canal.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates	Nitrogen. In nitrites	Colonies—per cc.	Fermentation. 1-10 cc. (Per cent.)	Fermentation. 1 cc. (Per cent.)	Fermentation. 1 cc. (Per cent.)	Coagulation of milk.	Indol produced?
74.6	10.30	2.30	None..	None..	199,200	....	None..	80	Rapid	No.
54.00	4.15	1.01	0.25	0.20	....	....	"	40	"	Yes.
78.10	13.60	1.70	None..	None..	74,000	....	"	None..	"	No.
78.10	10.45	2.34	"	"	262,500	....	5	10	"	"
103.00	14.00	2.48	"	"	480,000	....	50	40	"	"
81.70	15.36	1.84	"	Trace..	44,000	....	50	40	"	"
99.40	14.40	2.56	"	None..	410,000	....	35	85	"	"
163.00	18.80	3.16	"	"	Many millions	....	50	35	"	....
103.00	15.00	1.36	"	"	315,000	10	20	....	"	Yes.
99.40	13.60	2.04	"	"	29,000	10	15	....	"	"
88.75	19.40	3.32	"	"	26,000	None..	5	....	"	No.
95.85	17.80	1.10	"	"	96,600	10	10	....	"	Yes.
67.50	25.80	6.20	"	0.025	220,100	40	50	....	"	"
68.20	19.80	4.10	"	0.01	1,638,000	20	60	....	"	"
73.80	20.60	5.40	"	Trace..	1,060,800	40	70	....	Very rapid	"
96.00	23.20	3.40	"	0.02	35,260	60	15	....	24 hours	"
89.00	16.70	4.80	"	None..	1,688,400	40	40	....	Rapid	"
85.49	16.05	2.88	0.014	0.015						

The Kankakee River.

1.4	0.08	0.32	5.00	0.06	285,120	....	None..	None..	12 hours	No.
3.55	0.078	0.458	None..	Trace..	5,300	....	5	10	24 hours	"
3.55	0.13	0.368	"	0.01	3,850	....	30	5	Slow	"
4.26	0.114	0.328	"	0.04	780	....	40	40	Rapid	Yes.
2.84	0.07	0.298	"	None..	5,695	10	10	....	Slow	No.
2.84	0.064	0.362	0.20	0.01	59,500	None..	None..	....	"	"
2.48	0.07	0.348	None..	None..	6,600	20	10	....	Rapid	"
1.40	0.084	0.258	"	"	7,900	None..	10	....	Very slow	"
2.85	0.048	0.30	3.20	0.01	4,750	25	None..	....	"	"
2.79	0.082	0.337	0.93	0.014						

TABLE VII.—*Morris*

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water......	Air.........	In solution.	In suspension......	Total......	Not filtered	Filtered ...
1899											
July	5	Light...........	Bad	Flocculent..	......	......	......	......	390	8.32	......
"	11	....	....	....	......	......	......	......	482	11.84	10.08
* "	18	....	....	....	74°	74°	420	56	476	10.24	9.28
"	25	Nearly clear...	Bad	Lumpy......	79	83	440	12	452	9.12	8.80
†Aug.	1	Turbid	"	Light	79	74	436	16	452	9.44	6.88
"	8	Light	Faintly disagreeably.	Little	74	72	468	12	480	9.20	6.96
"	15	Dark	Faintly disagreeable.	Flocculent..	73	73	412	24	436	9.92	7.84
"	22	Light, clear....	Bad	" ..	72	74	396	20	416	7.84	6.64
"	29	Dark, clear.....	Good........	Light	78	76	428	20	448	8.08	6.80
Sept.	5	Light, clear....	Faintly disagreeable.	Little	77	78	370	42	412	8.64	6.56
"	12	Dark	Bad	Black	69	68	448	16	464	14.56	10.88
"	19	Light	"	Little	65	62	424	16	440	8.72	7.76
"	26	" turbid...	"	None........	62	51	476	12	488	12.32	9.28
Oct.	3	Dark, turbid...	"	"	55	61	456	20	476	28.80	20.16
"	10	Light, turbid ..	"	Little	58	68	480	32	512	9.92	7.92
"	17	" ..	"	None........	58	55	368	16	384	7.28	5 92
"	24	" ..	"	Dark........	......	......	316	88	404	7.92	7.52
"	31	" ..	"	Black, flocculent	50	48	414	20	434	11.36	7.84
Nov.	7	Light	"	Flocculent..	44	38	422	18	440	11.20	7.84
"	14	"	"	Lumpy bl'k.	46	54	426	14	440	12.00	8.48
"	21	Slightly dark..	"	Flocculent..	52	58	404	24	428	6.56	6.32
"	28	Light, turbid ..	"	Little	42	42	402	12	414	8.40	7.92
		Averages...	....	....	......	......	420	25	445	9.16	8.07

* Heavy rain for 4 days.

† Collected during a rain.

TABLE VIII.—*Ottawa* —

1899											
July	5	Dark yellow ...	Fair	....	......	......	......	.....	396	10.40	......
"	11	....	....	....	80.0°	......	......	......	466	9.44	9.44
* "	18	Yellow	Earthy.......	....	81.5	83°	344	28	372	8.48	7.04
"	25	Dark	"	Little	84.0	90	416	20	436	7.84	6.72
Aug.	1	"	Faintly disagreeable.	"	83.0	90	432	12	444	7.52	6.64
"	8	Light, clear....	Earthy.......	"	80.0	81	452	16	468	6 80	6.64
"	15	"	None.... ...	"	76.0	78	384	12	396	6.08	5 68
"	22	"	Little	"	84.0	92	468	16	484	7.68	7.12
"	29	Fairly light....	Not pleas'nt	"	85.0	90	444	4	448	7.28	6.48
Sept.	5	Dark yellow ...	Earthy......	Dark........	86.0	96	456	16	472	7.52	6.80
"	12	Light, clear....	None........	None........	73.0	72	504	12	516	6.80	6.16
"	19	"	Little	"	75.0	78	464	......	464	7.04	6.80
"	26	"	Faint........	"	64.0	65	440	4	444	7.12	6.64
Oct.	3	Clear, yellow ..	Bad	"	60.0	73	496	6	502	7.92	7.12
"	10	Light, clear....	Faint........	"	64.0	70	476	8	484	7.60	7.04
"	19	"	None........	"	......	......	414	8	422	6.24	6.00
"	24	"	Faint	"	68.0	80	440	2	442	5.68	5.32
"	31	"	"	"	50.0	48	400	4	404	4.88	4.52
Nov.	7	"	None........	"	46.0	59	400	20	420	4.56	4.56
"	15	"	Good........	"	48.0	58	404	28	432	6.00	5.92
"	21	"	Little	"	52.0	60	432	8	440	7.76	7.76
"	27	"	None........	"	42.0	50	420	4	424	6.40	......
		Averages...	....	....	......	......	434	11	445	7.13	6.52

* Heavy rain; river high.

The Illinois River.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates.	Nitrogen. In nitrites.	Colonies—per cc.	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
58.5	8.90	1.10	None..	None..	55,800	....	None..	None..	Rapid	No.
56.8	9.60	1.00	"	"	12,000	....	"	"	"	"
53.3	5.90	1.00	"	0.48	35,750	....	"	50	24 hours	"
49.7	9.50	1.36	"	0.12	115,000	....	"	None..	"	"
71.0	9.64	0.88	"	0.60	501,000	....	15	20	Rapid	"
63.9	11.00	1.16	"	2.40	320,000	....	20	90	"	"
63.9	10.60	1.24	"	0.006	188,000	....	90	90	Slow	"
63.9	6.20	1.16	"	None..	52,800	....	100	30	24 hours	....
81.7	10.50	0.88	"	0.03	61,500	....	25	30	Slow	....
81.7	10.56	1.24	"	Trace..	3,514,500	....	45	45	Rapid	....
74.6	10.50	1.28	"	None..	10,200	30	15	....	Very rapid	No.
71.0	6.00	0.76	"	Trace..	31,500	50	40	....	24 hours	"
81.7	9.50	1.72	"	None..	43,200	10	10	....	Rapid	"
43.9	12.00	1.28	"	0.015	489,600	10	60	....	"	Yes.
53.3	11.00	1.34	"	0.005	37,730	30	20	....	"	"
53.3	15.40	1.38	"	None..	56,700	5	80	....	"	"
67.5	8.60	0.72	"	Trace..	594,000	10	10	....	"	"
78.0	15.60	1.68	"	0.005	656,800	5	5	....	24 hours	No.
53.2	9.10	1.36	"	0.01	1,366,200	70	30	....	Rapid	Yes.
46.2	9.76	1.46	0.80	0.04	548,000	50	20	....	"	"
42.6	9.80	1.26	0.48	0.28	528,000	35	30	....	24 hours	"
49.7	12.50	1.29	0.32	Trace..	23,000	10	10	....	Slow	No.
61.8	10.99	1.20	0.07	0.18						

The Illinois River.

49.7	8.10	0.80	None..	0.005	1,740	....	25	5	24 hours	No.
49.7	3.90	0.90	"	0.005	3,710	None..	None..	None..	"	"
28.4	2.60	0.75	0.64	1.60	990	"	"	"	"	"
35.5	4.80	0.78	Trace..	0.36	15,200	....	"	"	"	"
51.8	5.28	0.56	1.25	6.40	5,400	....	30	90	Rapid	"
42.6	4.35	0.54	0.60	0.05	26,400	....	5	10	24 hours	"
50.4	3.93	0.46	0.48	0.50	7,600	....	50	90	19 hours	"
56.8	4.85	0.49	0.20	0.40	33,000	....	25	20	24 hours	"
78.1	3.75	0.52	1.60	0.20	270,000	....	5	10	Slow	....
85.2	5.55	0.69	0.40	0.05	371,000	....	40	30	Rapid	Yes.
53.3	5.50	0.44	0.72	0.40	33,300	50	40	....	"	"
71.0	8.80	0.62	2.00	0.20	2,050	60	20	....	"	"
67.5	7.15	0.37	0.60	0.30	7,500	20	20	....	24 hours	"
76.7	10.63	0.59	0.72	0.20	28,000	5	5	....	"	No.
69.3	10.60	0.66	0.40	0.10	260,700	5	10	....	Rapid	"
60.3	11.50	0.68	0.32	0.80	11,500	10	20	....	"	Yes.
71.0	5.20	0.54	0.60	0.28	35,260	60	15	....	24 hours	"
64.0	9.42	0.68	0.80	0.15	15,600	10	20	....	Rapid	No.
56.8	7.60	0.46	0.60	0.25	26,200	10	10	....	"	"
53.3	2.50	0.68	1.80	0.50	21,400	10	10	....	24 hours	"
42.6	4.16	0.60	2.00	0.70	6,600	5	10	....	48 hours	"
49.7	7.00	0.84	0.60	0.12	1,400	15	25	....	24 hours	"
57.4	6.23	0.62	0.74	0.61						

TABLE IX.—*Ottawa*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered
1899.											
July	5	Turbid	Good..	....	73°	73°	......	......	306	8.48	.....
* "	18	....	....	....	81	83	304	92	396	12.64	8.32
Aug.	1	Turbid	Good	Light	80	90	320	24	344	6.48	5.04
"	15	Light, turbid ..	"	Little.......	75	78	296	36	332	5.84	5.60
"	29	Light...........	"	"	84	90	324	24	348	6.56	5.12
Nov.	27	Light, clear....	"	None........	42	50	324	......	324	3.84	3.84
		Averages ..	....	....	......	......	314	35	349	7.30	5.58

* Heavy rains; high water

TABLE X.—*LaSalle*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered
1899.											
July	13	Straw	Earthy......	....	87°	85°	484	128	612	10.56	9.92
* "	20	....	....	....	84	82	444	44	488	8 48	6.88
"	27	Turbid..........	Good	Some	90	84	424	8	432	7.52	6.32
Aug.	2	Light...........	"	Granular ...	86	80	430	26	456	7.84	6.96
"	9	"	Earthy......	Little	78	84	400	20	420	6.96	6.00
"	16	Greenish, clear	Slightly unpleasant ..	"	82	76	404	8	412	6.88	6.08
"	23	Yellow	Faint	"	82	92	484	16	500	7.44	6.24
"	30	Light yellow ..	Good	....	86	84	436	12	448	6.72	6.32
Sept.	6	Yellow	"	Little	86	86	436	28	464	7.60	7.36
"	13	Light...........	"	Yellow......	70	68	444	32	476	6.56	6.08
"	20	"	"	None........	66	70	426	10	436	5.92	5.44
"	26	Dark	Little	"	62	70	416	16	432	6.88	6.56
ct.	4	Light...........	Bad	Little	62	80	436	4	440	7.68	7.44
"	11	"	Good	"	64	68	420	46	466	7.76	7.20
"	18	"	Faint........	None........	......	......	372	12	384	6.48	5.64
"	25	"	None........	"	65	82	376	16	392	6 16	5.76
Nov.	1	"	Little	"	53	45	354	10	364	5.04	4.96
"	8	"	Faintly disagreeable.	"	47	68	364	2	366	4.96	4.96
"	22	"	Bad	"	52	56	376	......	376	6.16	6.08
"	29	Light yellow ..	"	"	46	58	404	......	404	6.88	6.88
†Dec.	6	Yellow.	Good	Fine	32	30	388	12	400	6.40	6.32
		Averages ..	....	....	......	......	415	21	436	6.99	6.44

* Heavy rain; river 2 feet above normal.

† Ice upon river.

The Fox River.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates.	Nitrogen. In nitrites.	Colonies—per cc.	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
3.55	0.20	0.50	None..	None..	3,200	....	5	None..	Slow	No.....
2.84	0.072	0.72	0.48	0.02	3,280	....	None..	"	Very slow	"
4.26	0.06	0.338	None..	0.003	42,000	....	"	"	Slow	"
3.55	0.12	0.398	"	0.01	8,800	....	..	5	24 hours	"
3.55	0.13	0.428	"	0.01	17,200	....	10	5	Slow	....
4.97	0.29	0.34	0.20	Trace.	1,400	20	20	....	24 hours	No.....
3.78	0.145	0.454	0.11	0.007						

The Illinois River.

49.0	1.28	0,68	0.60	0.64	1,400	....	None..	None..	24 hours	No.....
30.5	1.75	0.71	2.00	0.32	3,500	....	"	"	12 hours	"
32.7	0.65	0.75	1.00	0.005	136,500	....	"	"	14 hours	"
32.0	1.50	0.61	1.00	1.00	46,200	....	40	60	24 hours	"
42.6	1.60	0.47	1.40	0.01	26,200	....	90	50	Rapid	"
46.2	0.95	0.62	1.92	0.20	12,800	....	30	5	"	"
53.3	2.40	0.74	1.60	0.20	1,500	....	50	100	24 hours.	"
56.8	1.95	0.55	1.60	0.40	....	....	35	20	Slow	"
46.2	4.05	0.56	4.00	Trace.	39,000	90	90	....	Very rapid	Yes....
60.4	4.35	0.42	0.60	0.32	1,525	60	5	....	Rapid	No.....
49.7	7.95	0.60	3.28	0.14	5,500	60	60	....	"	Yes....
42.6	9.50	0.28	1.00	0.15	6,400	80	80	....	"	"
42.6	5.00	0.38	1.00	0.02	14,220	10	50	....	"	No.....
39.8	9.80	0.66	1.60	1.00	6,400	None..	90	....	"	Yes....
37.0	10.10	0.58	0.68	1.50	16,250	60	40	....	"	"
46.1	4.80	0.88	2.40	0.20	5,700	30	20	....	24 hours	"
35.5	6.70	0.32	1.60	0.03	47.600	40	10	....	"	No.....
39.0	6.40	0.82	0.40	0.12	13,100	None..	10	....	"	"
25.0	4.60	0.44	1.40	0.16	1,800	10	40	....	"	Yes....
35.4	6.32	0.60	0.80	0.40	147,000	50	30	....	"	"
25.0	6.30	0.68	0.60	0.60	1,200	50	40	....	Rapid	"
41.3	4.66	0.58	1.45	0.35						

Table XI—*LaSalle*—

Date.	Color.	Odor.	Sediment.	Temperature. Water....	Temperature. Air........	Solids. In solution.	Solids. In suspension	Solids. Total......	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered...
1899.										
*July 13	Light yellow...	None........	Some........	85°	85°	496	24	520	3.68	3.36
† " 20	....	....	....	86	82	476	44	520	3.28	3.04
" 27	Light...........	Earthy......	Some........	90	84	552	64	616	2.72	2.24
Aug. 2	Light, turbid...	Good........	"	86	80	752	32	784	3.28	2.80
" 16	Dark	None........	"	80	76	652	44	696	4.08	2.48
" 23	Light...........	Good........	Sandy	82	92	616	40	656	3.76	2.96
‡Nov. 16	None	None........	None........	50	62	1.776	54	1.830	6.16	4.88
§Dec. 6	Light...........	Good........	"	33	40	1.672	20	1.692	1.84	1.84
	Averages...	....	....	......	......	874	40	914	3.60	2.95

* Bacterial sample warm.

† Heavy rains; river two feet above normal.

‡ Calcium, magnesium and SO_4 present in large amounts; CO_3 absent.

§ As above. About one inch of ice.

Table XII—*Henry*—

1899.										
July 10	....	....	Brown	......	......	......	......	426	9.60	......
" 17	Turbid	None........	Some........	78°	72°	388	12	400	9.60	8.16
" 31	Very turbid....	Good........	Little	......	......	448	32	480	6.40	6.16
*Aug. 7	Light...........	"	Granular ...	74	66	476	52	528	7.44	6.80
" 14	Dark	"	Dark........	70	68	432	44	476	6.24	5.36
" 21	Light, clear	Earthy......	Little	......	......	440	24	464	6.64	6.32
" 28	"	Bad	Brown	82	78	520	20	540	6.96	6.64
Sept. 4	Dark	Faint	Dark........	74	68	404	24	428	8.16	7.76
" 11	Light...........	Good........	Sandy	74	68	406	50	456	6.80	5.92
" 18	Turbid	Earthy......	None........	70	66	416	32	448	8 16	7.36
" 25	Light, turbid...	"	Little	66	60	404	36	440	8.64	8.08
Oct. 2	"	"	Scanty, yellow	56	52	420	20	440	6.80	6.08
" 9	"	None........	Little	58	50	556	6	562	6.56	6.00
" 16	Dark, clear.....	Faint	"	66	70	436	24	460	6.72	5.68
" 23	Light...........	Good........	"	60	66	420	18	438	5.68	5.44
" 30	Light, turbid...	Little	Gray	56	40	376	22	398	5.52	4.64
Nov. 13	Light, clear	Faintly disagreeable.	None........	48	40	380	28	408	5.04	5.04
" 27	"	Good........	"	46	32	380	......	380	6.16	6.08
Dec. 4	Light...........	None........	Little	36	32	374	10	384	5.92	5.68
	Averages...	....	....	......	......	426	25	451	7.00	6.28

* Sample warm.

The Vermilion River.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates	Nitrogen. In nitrites	Colonies—per cc	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
7.81	0.02	0.23	1.40	0.03	....	....	None..	None..	24 hours	No.
7.80	0.06	0.116	2.00	0.04	2,700	....	"	"	Slow	"
20.60	0.116	0.276	0.53	0.045	77,000	....	"	"	"	"
34.08	0.10	0.208	None .	0.01	72,600	....	50	35	Rapid	"
28.40	0.064	0.214	0.48	0.06	700	....	70	None..	Slow	"
34.10	0.16	0.318	None..	0.01	600	....	80	100	24 hours	"
95.90	0.814	0.106	0.24	0.02	1,200	5	50	....	Slow	"
78.10	0.96	0.126	0.24	0.60	13,400	None..	None..	....	"	"
38.35	0.286	0.199	0.61	0.102						

The Illinois River.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates	Nitrogen. In nitrites	Colonies—per cc	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
42.6	1.61	0.68	0.50	0.0025	2,120	....	None..	None..	24 hours	No.
37.6	2.60	0.600	0.75	0.24	....	....	"	"	"	"
31.2	0.12	0.478	0.40	0.12	3,600	....	50	60	Rapid	"
37.0	1.10	0.438	1.10	0.14	1,750	....	None..	90	16 hours	"
32.0	1.54	0.59	0.25	0.24	13,300	....	10	10	Slow	"
52.5	1.09	0.538	0.96	0.24	792,000	....	100	90	Very rapid	"
49.7	1.32	0.495	1.20	0.16	3,591,000	....	5	5	Rapid	....
51.5	1.45	0.445	1.88	0.32	7,400	....	10	5	"	....
32.0	1.16	0.37	1.00	0.06	650	90	20	....	12 hours	No.
60.4	2.04	0.535	3.00	0.32	19,250	50	60	....	Very rapid	Yes
56.8	1.08	0.61	2.00	2.00	750	20	30	....	Rapid	"
49.7	5.05	0.85	1.60	3.00	1,450	60	50	....	24 hours	"
42.6	8.74	0.55	3.60	0.20	1,700	40	50	....	Rapid	"
54 0	7.93	0.74	2.80	0.10	8,200	None..	50	....	"	"
46.2	6.50	0.50	2.00	2.00	12,600	95	80	....	24 hours	"
42.6	4.31	0 49	1.60	0.20	1,200	None..	45	....	Rapid	No.
39.0	6.48	0.48	None..	0.06	48,000	"	80	....	24 hours	"
35.4	3.98	0.47	0.60	0.06	4,500	"	None..	....	Very slow	"
28.4	4.08	0.65	1.20	0.36	13,200	"	55	....	24 hours	Yes.
43.2	3.28	0.553	1.39	0.517						

Tabel XIII—*Peoria Narrows*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered
1889											
July	5	......	......	Yellow	......	......	......	......	428	8.64	......
"	13	......	Earthy	"	......	......	432	52	484	10.56	10.24
* "	19	......	......	......	......	......	464	8	472	5.76	4.64
"	26	Turbid	Good	Yellow	......	......	336	46	382	6.56	5.44
Aug.	2	"	"	Little	......	......	404	8	412	6.72	5.68
"	9	Light, turbid	"	Fine	......	......	432	24	456	6.32	6.08
"	16	"	"	Clay	......	......	420	36	456	6.08	5.68
"	23	"	Little	Some	......	......	372	20	392	6.32	5.36
"	30	Light	Good	Little	......	......	364	16	380	7.52	6.08
Sept.	6	Clear, yellow	"	Brown	......	......	372	32	404	6.80	5.52
"	20	Light, turbid	"	Little	......	......	408	32	440	6.88	5.92
Oct.	4	"	"	Sandy	......	......	420	8	428	5.36	5.20
"	18	"	"	Little	......	......	412	20	432	7.44	6.08
Nov.	8	Yellow	Earthy	None	......	......	372	14	386	4.72	4.24
"	23	Light	Faint	Sandy	......	......	360	24	384	7.20	5.68
		Averages	......	......	......	......	398	24	422	6.86	5.46

*Rain, with river rising.

Table XIV—*Lower Peoria—Wesley*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered
1899											
July	5	......	......	Yellow	......	......	......	......	428	10.40	......
"	13	Turbid	Sour	......	......	......	480	24	504	16.64	12.80
"	19	......	......	......	84°	92°	416	140	·556	14.40	9.28
"	26	Turbid	Sour	Yellow	84	98	360	32	392	8.80	8.00
Aug.	2	Dark	Bad	"	82	92	380	32	412	13.04	10.64
"	9	"	" sour	Brown	74	84	388	44	432	9.28	7.28
"	16	Dark, turbid	"	Dark	74	84	452	36	488	20.48	11.92
"	23	Light, clear	"	Gray	80	84	428	28	456	10.88	8.00
"	30	Dark	"	Little	83	82	460	20	480	11.52	10.88
Sept.	6	"	"	Brown	82	96	396	20	416	7.12	6.00
"	13	Light, turbid	"	Lumpy, bl'k	70	70	400	36	436	18.56	13.12
"	20	Dark	"	Brown	68	72	408	76	484	17.12	10.72
"	27	Yellow	"	"	62	70	404	28	432	10.40	7.20
Oct.	4	Dark, turbid	"	Dark	60	70	522	56	578	27.84	18.24
"	11	Dark, yellow	"	Flocculent, brown	64	64	420	122	542	5.60	4.64
"	18	Dark	"	Dark	70	80	492	88	580	28.00	18.24
Nov.	1	Yellow	"	Yellow	50	48	540	132	672	41.12	30.08
"	8	Light, turbid	"	Flocculent	48	66	452	42	494	19.84	14.72
"	15	"	"	Dark	52	58	478	14	492	24.48	21.44
"	22	Yellow	"	"	54	58	462	70	532	29 12	19.84
"	29	Yellow, turbid	"	"	44	52	432	52	484	21.76	13.76
		Averages	......	......	......	......	438	55	493	17.44	12.84

*Rains and river rising.

†Heavy rain day before collection.

‡Steamboat passing.

§River rising.

The Illinois River.

Chlorine........	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates.	Nitrogen. In nitrites..	Colonies—per cc....	Fermentation. 1-10 cc. (Per cent).....	Fermentation. 1 cc. (Per cent).....	Fermentation. 1 cc. (Per cent).....	Coagulation of milk.	Indol produced.....
23.4	0.40	0.50	0.80	0.0025	3,960	....	20	10	24 hours............	No ....
32.0	0.50	1.20	None..	None..	480	....	None..	None..	"	" ....
39.0	0.50	0.43	2.00	0.04	34,200	....	"	"	Slow	" ....
26.3	0.40	0.525	0.70	0.44	4,300	....	"	"	"	" ....
30.5	0.15	0.32	1.25	0.06	2,800	....	10	5	24 hours............	" ....
24.9	0.39	0 37	1.00	0.01	4,280	....	85	90	Slow	" ....
28.4	0.36	0.545	1.12	0.30	6,600	....	None..	15	"	" ....
28.4	0.35	0.46	0.80	0.12	2,800	....	100	100	"	" ....
35.5	0.385	0.67	0.44	0.06	31,900	....	5	30	24 hours............	" ....
24.9	0.725	0.735	0.40	0.12	40,600	None..	70	....	12 hours............	" ....
42.6	0.15	0.705	1.20	0.11	3,820	20	20	....	Slow	Yes....
31.2	0.365	0.57	1.60	0.70	200	None..	60	....	24 hours............	No ....
39.8	0.39	0.645	3.20	0.07	864,350	70	80	....	Slow	" ....
46.2	3.815	0.425	1.20	0.03	93,800	None..	10	....	24 hours............	" .. .
42.6	4.55	0.49	0.80	0.03	5,400	20	30	....	Slow	" ....
33.04	0.895	0.572	1.10	0.141						

The Illinois River.

17.8	0.60	0.85	None..	0.003	43,200	....	None..	None..	Rapid	No ....
17.8	0.75	2.80	"	None..	691,200	....	10	40	12 hours............	" ....
35.5	2.00	1.38	"	0.08	231,000	....	50	50	"	" ....
24.9	1.00	1.00	0.70	0.20	1,023,000	....	30	25	14 "	" ....
28.4	2.15	1.24	None..	None..	3,255,000	....	40	75	12	" ....
25.6	0.32	1.04	0.45	0.06	36,300	....	20	25	Rapid	" ....
32.0	3.45	2.74	None..	0.004	3,780,000	....	10	10	"	" ....
32.0	1.25	1.04	"	None..	3,528,000	....	20	25	"	" ....
35.5	0.64	1.32	"	"	7,268,000	....	20	50	"	" ....
42.6	0.87	0.56	0.28	0.10	280,000	5	50	....	"	Yes....
35.5	0.62	2.19	None..	None..	63,000	5	5	....	Very rapid.........	" ....
21.3	2.80	3.08	Trace..	0.003	1,015,000	30	50	....	Rapid	No ....
49.7	1.00	1.60	0.80	0.10	903,000	5	5	....	"	Yes....
39.0	6.86	4.28	None..	None..	1,108,000	None..	None..	....	"	No ....
48.3	3.90	7.08	"	"	23,688,000	"	10	....	24 hours............	" ....
39.0	10.20	7.76	"	"	347,000	90	20	....	Rapid	Yes....
42.6	13.92	7.04	"	"	1,138,500	5	10	....	"	" ....
46.2	7.60	4.88	"	"	646,000	None..	10	....	"	" ....
39.0	7.88	4.20	"	"	923,000	"	5	....	"	" ....
49.7	13.60	7.00	"	"	576,000	10	10	....	"	" ....
32.0	10.20	4.20	"	"	1,173,000	20	20	....	"	" ....
34.97	4.36	3.20	0.106	0.026						

Table XV—*Pekin*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Oxygen Absorption.	
					Water....	Air........	In solution.	In suspension.....	Total.....	Not filtered	Filtered....
1899.											
July	18	....	....	....	79°	90°	440	20	460	8.16	7.68
*Aug.	1	Turbid	Earthy......	Some	82	94	396	12	408	7.76	6.88
"	8	Light, clear....	Slight.......	Clay	70	74	424	20	444	6.96	6.48
"	15	"	Good	Little	77	92	396	28	424	6.48	6.24
"	22	Dark	None........	Brown	79	91	396	8	404	6.88	6.08
† "	30	Green	Bad	Green.......	86	100	440	56	496	20.96	10.72
Sept.	5	Light...........	None........	Sandy	82	100	360	32	392	8.48	6.64
"	12	"	Bad	Fine	68	80	388	36	424	7.36	6.72
"	19	Light yellow...	Earthy......	Clay	68	70	356	40	396	7.12	5.84
"	26	Dark	"	Brown	59	65	384	32	416	8.48	6.88
Oct.	3	Clear, yellow ..	Good........	Yellow......	54	75	394	20	414	6.00	5.68
"	10	Light...........	"	"	54	.71	368	16	384	6.16	6.16
"	18	Light, turbid..	Faintly disagreeable.	Little	59	70	394	22	416	7.88	6.96
"	25	Yellow, turbid.	Disagr'able.	Sandy	61	58	414	38	452	8.40	5.76
"	31	Yellow, clear..	Peculiar	Little	50	58	416	24	440	7.84	6.40
Nov.	7	Yellow	Bad	"	43	59	394	28	422	6.56	5.84
‡ "	15	Light...........	Good........	Sandy	50	68	384	36	420	6.16	4.88
"	22	"	Little	Brown	50	42	380	4	384	5.44	5.12
"	30	Light, not clear	Bad	Flocculent..	.....	48	352	16	368	5.36	4.88
		Averages...	....	....	......	......	393	26	419	7.81	6.41

* Collected during a shower.
† Bottle containing bacterial samples broken.
‡ Light showers.

Table XVI—*Havana*—

Date.		Color.	Odor.	Sediment.	Water.	Air.	In solution.	In suspension.	Total.	Not filtered	Filtered.
1899.											
July	6	....	....	Clay	......	......	......	......	734	9.44	......
* "	13	Slightly dark..	None........	Feathery ...	80°	86°	396	116	512	9.44	9.28
"	20	....	....	....	80	85	448	36	484	9.60	8.96
"	27	Light, turbid...	Good	Little	85	90	308	44	352	7.52	7.04
Aug.	3	Turbid	"	Fine	80	84	348	60	408	6.56	5.28
† "	10	"	Little	"	74	78	416	24	440	6.72	6.08
"	17	Cloudy, dark...	Good	Dark	78	84	392	76	468	6.64	6.24
"	24	Light, turbid..	Earthy......	Light brown	76	78	388	72	460	6.96	5.76
"	31	" ..	Good	Little	74	78	388	52	440	6.40	6.16
Oct.	5	" ..	Earthy......	Sandy	50	50	340	20	360	5.44	4.32
"	12	Yellow	"	Yellow......	62	70	408	68	476	6.96	6.40
"	18	"	Little	Dark	48	52	376	56	432	8.08	6.96
‡ "	26	Dark yellow...	"	Sandy	58	64	400	68	468	6.48	5.52
Nov.	2	Yellow, unclear	Faint........	Light	44	34	402	90	492	7.12	5.76
"	16	Dark yellow ...	Earthy......	Dark yellow	50	56	398	22	420	7.52	6.64
"	30	Light yellow...	Slightly disagreeable.	Sandy	46	50	344	28	372	5.84	5.12
Dec.	7	Dark....	Little........	"	36	44	364	12	376	5.92	5.60
§ "	14	Yellow	None........	"	32	30	356	20	376	6.64	6.24
		Averages ..	....	....	......	......	381	51	432	7.18	5.96

* Bacterial sample warm.
† Storms.
‡ Rain at time of collection.
§ Snow.

The Illinois River.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates.	Nitrogen. In nitrites.	Colonies—per cc.	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
28.4	0.85	0.45	None..	0.280	52,500	....	10	10	24 hours............	No ....
24.9	0.87	0.67	" ..	0.320	665,000	....	10	15	"	" ....
24.9	0 82	0.59	0.50	0.015	778,000	....	10	20	Rapid	" ....
17.8	0.85	0.49	0.48	0.080	289,000	....	20	40	"	" ....
35.5	0.70	0.97	0.88	0.160	7.200	....	10	15	"	" ....
39.0	0.37	2.74	None..	None..	....	....	....	....	....	....
42.6	0.83	0.87	" ..	0.080	291,000	....	50	40	Rapid	Yes ...
24.9	1.32	0.64	" ..	None..	36,000	20	20	....	"	" ....
39.0	0.75	0.62	0.48	0.080	326,000	25	15	....	"	" ....
32.0	0.63	0,54	0.48	0.100	224,000	15	20	....	"	" ....
37.0	0.60	0.54	1.00	0.120	148,000	40	50	....	"	" ....
31.2	1.05	0.82	1.00	0.300	260,700	50	50	....	24 hours............	" ....
31.2	1.33	0.94	1.40	0.400	300,000	5	10	....	"	No ....
50.0	1.80	0.92	1.40	0.460	257,400	10	20	....	"	Yes ...
46.0	0.73	0 81	2.50	1.200	72,600	None..	50	....	"	No ....
49.7	2.50	0.56	0.80	1.200	63,900	15	35	....	"	Yes ...
42.6	3.31	0.60	1.00	0.050	8,200	None..	10	....	"	No ....
39.0	4.50	1.45	1.00	0.200	14,000	" ..	30	....	Rapid	" ....
24.9	2.75	0.50	0,60	0.200	2,378,500	10	10	....	48 hours............	" ....
34.76	1.39	0.828	0.71	0.273						

The Illinois River.

15.6	1.76	0.82	None..	Trace.	1,800	....	None..	None..	24 hours............	No ....
22.7	1.50	1.05	1.20	0.06	....	....	" ..	" ..	16 "	" ....
32.7	1.15	0.35	1.20	0.28	39,600	....	" ..	" ..	12 "	" ....
23.4	0.82	0.57	0.67	0.24	79,200	....	" ..	" ..	24 "	" ....
21.3	1.05	0.44	1.00	0.12	56,000	....	50	50	Rapid	" ....
21.3	1.00	0.46	0.80	0.02	81,600	....	50	60	24 hours............	" ....
24.9	1.30	0.41	0.40	0.08	26,400	....	60	50	14 "	" ....
24.9	0.90	0.69	0.28	0.12	59,400	....	90	90	Rapid	" ....
28.4	0.70	0.52	0.48	Trace.	....	....	40	20	"	Yes ...
25.0	0.45	0.54	0.52	0.02	59,500	40	50	....	"	" ....
38.3	0.47	0.67	1.60	0.60	42,000	25	60	....	24 hours............	" ....
39.0	1.08	0.99	2.00	0.01	9,750	90	60	....	Rapid	" ....
46.2	1.72	0.86	1.60	0.03	35,360	90	90	....	"	" ....
44.4	2.18	0.83	1.60	0.25	323,400	5	10	....	"	" ....
35.4	4.08	0.95	2.00	1.00	42,200	20	30	....	24 hours............	No ....
35.4	3.75	0.95	0.48	0.20	363,000	20	29	....	"	" ....
21.3	2.65	0.62	1.00	0.70	301,000	10	.10	....	"	" ....
24.9	3.95	0.80	1.60	0.12	....	....	....	....	....	....
29.17	1.69	0.695	1.02	0.21						

Table XVII.—*Havana—*

Date.	Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered
1899.										
Sept. 7	Light	Good	Dark	84°	88°	280	76	356	5.44	4.48
" 14	"	Earthy	Sandy	52	68	260	122	382	6.48	4.72
" 21	Clay	Good	Clay	58	52	164	564	728	12.96	6.
" 28	Light	"	Yellow	54	52	228	66	294	6.48	4.56
	Averages					233	207	440	7.84	4.94

Table XVIII.—*Browning—*

Date.	Color.	Odor.	Sediment.	Water	Air	In solution	In suspension	Total	Not filtered	Filtered
1899.										
July 6			Yellow					428	5.28	
" 20				81°	82°	332	44	376	3.52	2.56
Aug. 3	Light, turbid	Good	Fine granular	89	91	302	30	332	3.44	3.12
" 17	Turbid	"	Dark	83	87	292	48	340	4.16	3.60
Sept. 1	Dark	"	Little	86	87	376	8	384	5.12	4.88
*Nov. 9	Light	None	None	51	65	310	18	328	3.76	3.44
† " 23	"	Good	Sandy	52	48	292	28	320	3.36	2.96
	Averages					317	29	346	4.09	3.42

* River had risen some.
† Rain; river high.

Table XIX.—*Pearl—*

Date.	Color.	Odor.	Sediment.	Water	Air	In solution	In suspension	Total	Not filtered	Filtered
1899.										
July 7		Fair	Clay					382	6.40	
* " 14	Turbid	Earthy		86°	86°	312	64	376	6.40	5.76
" 21	"	Good	Clay	84	90	340	88	428	6.00	5.84
† " 28	Light	"	Little	87	91	428	16	444	5.76	4.64
Aug. 3	" very turbid	"	Heavy	88	98	284	72	356	5.12	4.48
‡ " 10	Yellow	Earthy	Heavy clay	78	82	196	396	592	8.48	5.92
" 18	Light, turbid	Bad	Some	86	92	324	48	372	4.64	4.00
§ " 24	Very turbid	Good	Clay	86	90	324	72	396	5.28	4.16
" 31	Light, turbid	"	Sandy			284	32	316	4.48	4.24
**Sept. 7	Light	None	"	92	100	312	40	352	5:12	4.56
" 14	Light, turbid	Good	"	76	74	340	40	380	5.76	5.28
" 21	"	"	Yellow	70	74	292	76	368	4.88	4.56
Oct. 5	"	Earthy	Yes	64	74	310	32	342	4.32	4.08
†† " 12	Light, not clear	Good	Sandy	67	80	326	28	354	5.68	4.96
‡‡ " 19	"	"	Light	67	77	272	16	288	4.32	4.00
" 26	Yellow	None	Sandy	67	68	324	66	390	5.20	4.96
§§Nov. 2	"	Good	Yellow	52	32	356	48	404	4.88	4.32
" 16	Light, turbid	"	Clay	54	72	368	64	432	6.56	4.72
	Averages					317	71	388	5.51	4.73

*Sample warm, light rain.
†Shower night before.
‡Violent storms, floods.
§River low.
**Sample arrived two days late and warm.
††Bacillus coli communis separated and identified.
‡‡Water collected during a rain.
§§Blizzard and snow storm.

The Spoon River.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates	Nitrogen. In nitrites	Colonies—per cc	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
1.06	0.31	0.184	0.36	None..	4,100	50	100	....	Rapid	No.....
5.68	0.43	0.308	None..	0.05	1,100	60	60	....	24 hours	"
7.8	0.392	0.944	0.40	0.09	5,150	None..	5	....	Slow	"
2.13	0.078	0.548	0.32	0.02	6,200	"	None..	....	"	"
4.17	0.302	0.496	0.27	0.04						

The Sangamon River.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates	Nitrogen. In nitrites	Colonies—per cc	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
4.97	0.10	0.50	None..	None..	1,040	....	20	10	Slow	No.....
4.26	0.12	0.192	0.50	0.01	1,640	....	None..	None..	24 hours	"
4.26	0.05	0.258	None..	0.02	650	....	10	25	"	"
3.55	0.08	0.264	"	0.06	6,600	....	50	70	Slow	"
27.00	0.35	0.388	0.48	0.10	....	....	5	10	"	"
4.25	0.09	0.314	0.28	Trace..	2,200	None..	10	....	"	"
5.68	0.232	0.324	0.32	None..	800	80	10	....	"	"
*7.71	0.146	0.320	0.22	0.03						

* 4.49 average—exclusive of Sept. 1.

The Illinois River.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates	Nitrogen. In nitrites	Colonies—per cc	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
9.38	0.11	0.46	0.77	None..	294,400	....	10	5	Rapid	No.....
10.70	0.12	0.52	0.80	"	....	....	5	None..	24 hours	"
18.50	0.062	0.39	1.20	0.04	31,500	....	None..	"	"	"
27.70	0.014	0.126	1.00	Trace..	15,700	....	"	"	Rapid	"
14.90	0.11	0.318	0.75	0.14	2,700	....	30	25	Slow.	"
8.52	0.64	1.02	0.50	None..	140,000	....	30	40	24 hours	"
15.60	0.28	1.09	0.80	0.10	55,600	....	None..	5	Slow	"
17.00	0.076	0.348	0.48	0.08	....	....	"	70	Rapid	"
14.20	0.13	0.308	0.52	Trace..	....	....	5	40	"	Yes....
17.80	0.19	0 254	0.32	None..	585,000	50	50	....	"	"
17.80	0.076	0.578	0.44	0.005	100	None..	90	....	"	No.....
7.10	0.55	0.398	0.52	0.07	3,850	"	10	....	24 hours	"
11.40	0.136	0.374	0.60	0.01	400	"	None..	....	Slow	"
31.20	0.43	0.584	0.28	0.01	1,350	"	50	....	"	Yes....
18.00	0.154	0.458	0.80	0.04	49,000	25	30	....	"	No.....
30.00	0.70	0.404	1.20	0.04	11,200	None..	15	....	Very slow	"
28.40	0.65	0.53	1.80	0.60	2,700	"	None..	....	"	"
39.00	1.25	3.95	1.40	0.01	2,900	50	90	....	48 hours	"
18.73	0.315	0.672	0.79	0.06						

TABLE XX.—*Grafton*

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered
1899.											
July	10	Turbid	......	Yellow	80°	84°	......	......	296	5.92	......
"	17	"	Good	Some	87	92	288	36	324	5.76	5.12
"	24	Straw	"	"	85	82	296	24	320	4.64	4.16
* "	31	Light	"	Yellow	84	71	400	28	428	5.20	4.32
Aug.	7	"	"	"	83	77	320	40	360	5.44	4.80
"	14	Yellow	"	Heavy clay	79	80	140	236	376	7.20	5.52
"	21	Light turbid	"	Yellow	87	87	304	36	340	4.80	3.76
"	28	"	"	Little	87	92	348	28	376	6.08	4.64
Sept.	4	"	None	Yellow	89	92	304	52	356	6.32	5.76
"	11	"	"	Little	78	82	310	20	330	5.44	4.96
"	18	"	Good	"	72	66	348	8	356	5.68	4.72
"	25	"	None	"	66	62	272	68	340	5.60	4.56
Oct.	3	"	Good	Yellow	56	72	272	36	308	4.80	4.64
"	9	"	"	Light	60	74	384	28	412	4.80	4.72
"	16	"	"	Brown	72	60	324	36	360	4.16	3.92
† "	23	"	"	Little	......	......	320	30	350	4.16	2.16
‡ "	30	Light yellow	"	Heavy	......	......	220	204	424	6.88	5.28
Nov.	6	Yellow	"	Light	48	56	332	28	360	5.04	4.40
"	13	Light yellow	"	Yellow	50	54	308	80	388	6.96	4.96
§ "	20	Yellow	"	Sandy	54	58	336	50	386	7.12	4.32
¶ "	28	Very turbid	None	Light	48	50	292	60	352	5.92	5.32
		Averages	......	......	......	......	306	56	362	5.61	4.65

* Rain.
† Rain during 38 hours before collection.
‡ River rising.
§ Rain.
¶ No ice used in packing.

TABLE XXI.—*Grafton*

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered
1899.											
July	10	Yellow	Good	Clay	78°	84°	......	......	328	15.52	......
"	17	"	"	"	80	92	164	154	320	11.20	9.44
"	24	"	"	"	85	82	180	164	344	6.88	6.40
* "	31	"	"	"	80	71	176	172	348	7.04	6.32
Aug.	7	Light	"	Yellow	81	77	200	68	268	7.20	6.32
"	14	"	"	Clay	78	80	148	232	380	7.60	6.08
"	21	"	"	Yellow	83	87	176	76	252	6.64	5.44
"	28	Light turbid	"	Slight	83	92	164	64	228	6.32	5.12
Sept.	11	"	"	Sandy	75	82	168	104	272	7.12	5.28
"	25	"	None	Little	65	62	168	84	252	8 16	7.04
Oct.	9	Light	Good	Clay	59	74	172	64	236	7.80	7.60
Nov.	6	Yellow	"	"	46	56	164	76	240	7.66	6.80
"	20	Light yellow	"	Sandy	52	58	144	52	196	11.68	10.08
		Averages	......	......	......	......	169	109	278	8.52	6.82

* Rain.

The Illinois River.

Chlorine........	Ammonia. Free........	Albuminoid	Nitrogen. In nitrates.	In nitrites..	Colonies—per cc....	Fermentation. 1-10 cc (Per cent).....	1 cc. (Per cent).....	1 cc. (Per cent).....	Coagulation of Milk.	Indol produced......
9.2	0.11	0.32	0.70	None..	6,500	....	None..	None..	Very slow..........	No.....
9.2	0.042	0.35	None..	0.04	....	....	"	"	Slow................	" ....
14.9	0.096	0.56	0.58	None..	4,850	....	"	"	"	" ....
30.5	0.11	0.358	1.20	0.06	5,600	....	"	"	"	" ....
16.3	0.08	0.338	0.75	0.07	10,800	....	10	20	16 hours............	" ....
4.3	0.154	0.514	0.40	0.04	3,250	....	20	10	Very slow..........	" ....
12.8	0.106	0.478	0.40	0.05	16,500	....	20	10	12 hours............	" ....
14.9	0.102	0.418	0.24	0.04	2,709,000	....	5	10	Rapid...............	" ....
12.4	0.30	0.478	0.40	0.10	900	....	None..	None..	Slow................	" ....
17.0	0.19	0.318	Trace..	0.05	211,400	70	90	....	24 hours............	" ....
19.9	0.24	0.328	0.60	0.05	925	10	15	....	Slow................	" ....
19.2	0.38	0.314	0.60	0.03	3,400	None..	None..	....	Very slow..........	" ....
10.7	0.206	0.418	0.48	0.15	350	"	90	....	24 hours............	" ....
17.0	0.164	0.328	0.80	0.03	17,200	"	10	....	Slow................	" ....
17.0	0.188	0.388	0.60	0.015	3,200	10	10	....	"	" ....
18.0	0.174	0.414	0.52	0.01	3,100	100	25	....	24 hours............	Yes....
12.5	0.386	0.584	1.20	0.10	18,300	10	10	....	Slow................	No.....
25.0	0.628	0.372	0.48	0.04	4,200	5	60	....	"	Yes ...
33.7	0.244	0.852	1.20	0.02	810	50	10	....	24 hours............	No.....
32.0	0.284	1.00	0.80	0.03	2,500	None..	10	....	Slow............	" ....
21.3	1 02	0.44	0.40	Trace .	48,000	80	35	....	Rapid..............	" ....
17.50	0.247	0.455	0.59	0.044						

The Mississippi River.

2.13	0.11	0.46	None..	None..	10,450	....	None..	None..	24 hours............	No.....
2.13	0.068	0.43	"	"	....	....	"	"	Slow................	" ....
1.42	0.076	0.56	"	"	13,600	....	"	"	Very slow..........	" ....
1.42	0.07	0.388	"	"	550	....	"	"	"	" ....
1.78	0.076	0.418	"	"	17,500	....	"	"	12 hours............	" ....
2.13	0.13	0.558	0.15	Trace .	1,100	....	25	30	Slow................	" ....
2.13	0.10	0.356	None..	None..	1,700	....	10	None..	"	" ....
1.78	0.08	0.348	"	"	5,859,600	....	50	45	Rapid..............	....
1.42	0.082	0.328	"	"	1,050	90	90	....	24 hours............	No.....
1.42	0.036	0.512	0.20	0.003	1,180	5	5	....	Very slow..........	" ....
2.13	0.056	0.458	Trace .	None..	9,210	None..	10	....	"	" ....
1.06	0.09	0.476	None..	0.01	6,600	"	50	....	24 hours............	" ....
2.15	0.076	0.466	"	Trace .	1,200	"	90	....	Very slow..........	" ....
1.77	0.08	0.443	0.03	0.001						

TABLE XXII.—*South Bend, Indiana—*

Date.	Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution.	Solids. In suspension	Solids. Total	Oxygen absorption. Not filtered	Oxygen absorption. Filtered
1899.										
*Nov. 9	Light, clear	None	None	......	......	472	14	486	5.44	5.44
" 19	"	Good	Flocculent	......	......	398	6	404	4.64	3.84
†Dec. 17	Yellow	"	Lumpy	......	......	400	8	408	6.88	6.88
	Averages					423	9	432	5.65	5.38

* Bacterial sample warm.
† Much snow and rain.

TABLE XXIII.—*McHenry—*

1899.										
Nov. 10	Light	Good	Sandy	50°	50°	284	40	324	6.32	5.92
" 24	Light yellow crystal clear.	"	None	40	40	280	12	292	4.48	4.48
Dec. 7	Light, clear	"	"	40	42	344	......	344	4.40	4.40
	Averages					303	17	320	5.06	4.93

TABLE XXIV.—*Libertyville—*

1899.										
Nov. 24	Light	Good	None	......	......	368	8	376	6.56	6.48
Dec. 19	Light, clear	"	"	......	......	448	8	456	4.96	4.80
" 28	"	"	"	......	......	564	26	590	5.84	5.44
1900.										
Jan. 4	Light	"	Little	......	......	668	20	688	3.36	2.80
	Averages					512	15	527	5.18	4.88

TABLE XXV.—*Mahomet—*

1899.										
*Nov. 1	Light	Earthy	Sandy	68°	40°	372	36	308	6.56	5.12
† " 15	"	Good	"	50	56	318	32	350	2.96	2.48
" 22	Light and slightly turbid	"	Light	62	58	308	64	372	5.12	3.28
	Averages					299	44	343	4.88	3.62

* Bacterial sample warm.
† ½ inch rain fall day before collection.

SOURCES.

The Kankakee River.

Chlorine........	Ammonia. Free	Albuminoid	Nitrogen. In nitrates.	In nitrites.	Colonies—per cc....	Fermentation. 1-10 cc. (Per cent).....	1 cc. (Per cent)	1 cc. (Per cent).....	Coagulation of Milk.	Indol produced......
1.40	0.060	0.25	1.8	Trace..	46,200	40	50	....	24 hours	Yes,...
1.07	0.054	0.22	None..	None..	1,600	40	40	....	Rapid	No,....
1.06	0.076	0.32	7.2	Trace..	30,400	40	50	....	Slow	Yes....
1.17	0.063	0.29	3.0	....						

The Fox River.

4.25	0.096	0.51	None..	None..	20,100	60	40	....	20 hours	No.....
3.54	0.094	0.37	" ..	" ..	2,600	None..	None..	....	Slow	" ....
2.80	0.25	0.384	" ..	" ..	32,000	Little..	" ..	....	"	" ....
3.53	0.147	0.421								

The DesPlaines River.

4.30	0.104	0.41	Trace..	None..	1,400	100	10	....	Rapid	No.....
1.10	0.086	0.34	0.16	0.02	9,000	15	10	....	24 hours	" ....
1.40	0.058	0.51	Trace..	0.03	6,200	5	5	....	Slow	" ....
6.40	0.076	0.57	None..	0.04	3,700	None..	10	....	24 hours	" ....
3.30	0.081	0.46	Trace..	0.02						

The Sangamon River.

0.90	0.22	0.47	None..	0.005	27,700	80	50	....	Slow	Yes....
2.50	0.05	0.28	" ..	None..	14,300	20	10	....	24 hours	No.....
2.15	0.13	0.34	Trace..	" ..	4,500	None..	None..	....	Slow	" ....
1.85	0.13	0.36	....	0.002						

Table XXVI.—*Kappa*—

Date.	Color.	Odor.	Sediment.	Temperature. Water	Air	Solids. In solution	In suspension	Total	Oxygen Absorption. Not filtered	Filtered
1899										
*Nov. 2	Light, unclear.	Good	Sandy	40°	44°	290	42	332	5.52	4.48
Dec. 14	Dark	"	Brown	34	45	332	48	380	6.56	5.44
	Averages					311	45	356	6.04	4.96

* Sample warm.

Table XXVII—*Dahinda*—

Date.	Color.	Odor.	Sediment.	Temperature. Water	Air	Solids. In solution	In suspension	Total	Oxygen Absorption. Not filtered	Filtered
1899										
*Nov. 9	Light	Earthy	Sandy	50°	53°	352	44	396	4.88	4.40
* " 24	Little	Good	Light			372	32	404	4.24	3.92
†Dec. 9	Light, nearly clear	"	Little	33	44	336	18	354	3.60	2.96
	Averages					353	31	384	4.24	3.76

* Bacterial sample warm. Not iced.

† Bacterial sample warm. Not iced. Rain beginning to fall

Table XXVIII—*Pontiac*—

Date.	Color.	Odor.	Sediment.	Temperature. Water	Air	Solids. In solution	In suspension	Total	Oxygen Absorption. Not filtered	Filtered
1899										
*Nov. 9	Light	Good	None	49°	72°	318	6	324	3.52	2.88
† " 24	Dark	"	Sandy	48	46	328	24	352	4.40	2.96
‡Dec. 8	Light	"	Little	40	59	388	10	398	3.68	3.12
	Averages					345	13	358	3.86	2.98

* From river above dam and above where sewage enters stream at Pontiac.

† From intake in river for pumping station of city water works. Bacterial sample warm Hard rain one week before collection.

‡Thin ice upon river.

Table XXIX—*Winfield*—

Date.	Color.	Odor.	Sediment.	Temperature. Water	Air	Solids. In solution	In suspension	Total	Oxygen Absorption. Not filtered	Filtered
1899										
Nov. 9	Light	Good	Brown	52°	50°	444	64	508	6.40	3.28
" 23	Light, turbid	"	Little	46	40	458	20	478	3.04	2.56
Dec. 7	Light	"	"	40	34	550	10	560	1.68	1.44
	Averages					484	31	515	3.70	2.42

The Mackinaw River.

Chlorine......	Ammonia.		Nitrogen.		Colonies—per cc....	Fermentation.			Coagulation of Milk.	Indol produced?....
	Free......	Albumenoid	In nitrates.	In nitrites..		1-10 cc. (Per cent.)....	1 cc. (Per cent.)....	1 cc. (Per cent.)....		
1.42	0.154	0.446	None..	Trace..	14,000	60	50	....	24 hours............	Yes....
4.24	0.176	0.540	1.40	0.03	30,300	5	None..	....	Slow................	No.....
2.83	0.165	0.493	0.70	0.015						

The Spoon River.

9.58	0.130	0.29	0.56	None..	40,100	90	30	....	24 hours............	Yes....
12.80	0.090	0.35	None..	" ..	69,000	15	50	....	Rapid	No.....
7.10	0.076	0.206	0.48	" ..	208,400	40	30	....	"	Yes....
9.82	0.098	0.282	0.52							

The Big Vermilion River.

2.84	0.160	0.24	None..	Trace..	4,900	None..	25	....	Slow................	No.....
3.54	0.102	0.22	" ..	None..	36,000	50	10	....	Rapid	Yes....
2.80	0.090	0.28	2.8	" ..	13,240	10	10	....	"	No.....
3.06	0.117	0.24	0.9	Trace..						

*West DuPage River.**

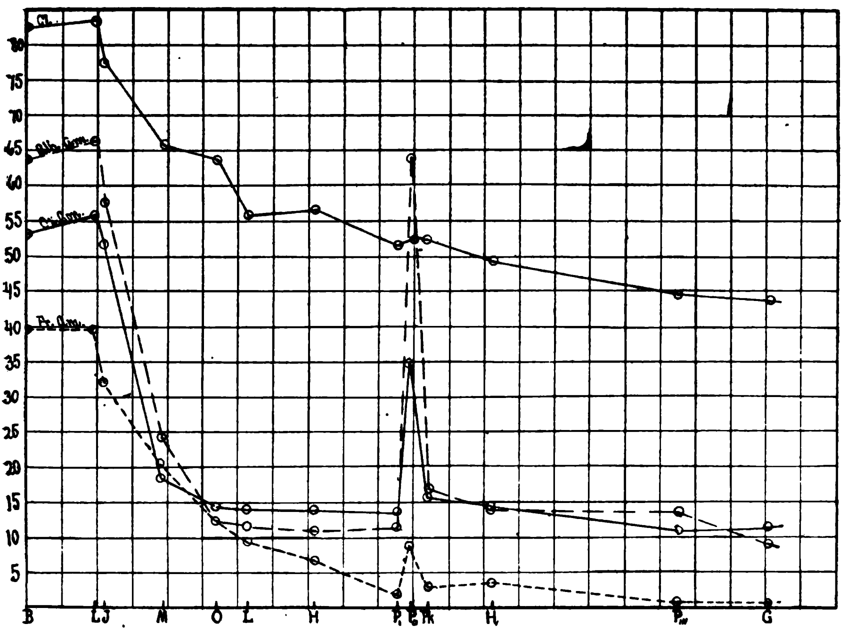
2.80	0.14	0.35	None..	None..	28,800	None..	5	....	Slow................	No.....
1.42	0.024	0.24	" ..	" ..	2,200	" ..	10	....	Rapid	" ....
7.10	0.246	0.10	" ..	0.03	17,000	15	None..	....	Slow................	" ....
3.77	0.136	0.23	....	0.01						

* Stream twenty (20) feet wide; ten inches of water.

Table XXX—Averages, 1899.

	Total solids..	Oxygen Absorption.		Chlorine.....	Free ammonia.....	Alb. ammonia	Nitrogen in nitrates....	Nitrogen in nitrites....
		Not filtered..	Filtered					
Bridgeport, canal	536.5	26.65	15.95	95.47	19.84	3.22		0.08
Lockport, canal	538.0	27.90	17.31	96.97	19.85	3.37	0.03	0.03
Lockport, DesPlaines	389.0	8.05	6.96	5.98	0.229	0.559	0.045	0.009
Joliet	591.0	25.09	15.10	85.49	16.05	2.88	0.014	0.015
Wilmington	322.0	5.71	5.09	2.79	0.082	0.337	0.93	0.014
Morris	445.0	9.16	8.07	61.80	10.09	1.20	0.07	0.18
Ottawa, Illinois	445.0	7.13	6.52	57.4	6.23	9.62	0.74	0.61
Ottawa, Fox	349.0	7.30	5.58	3.78	0.145	0.454	0.11	0.007
LaSalle, Illinois	436.0	6.99	6.44	41.30	4.66	0.58	1.45	0.35
LaSalle, Big Vermilion	914.0	3.60	2.95	38.35	0.286	0.199	0.61	0.102
Henry	451.0	7.00	6.28	43.20	3.28	0.553	1.39	0 517
Peoria, Narrows	422.0	6.86	5.46	33.04	0.895	0.572	1.10	0.141
Peoria, Wesley	493.0	17.44	12.84	34.97	4.36	3.20	0.106	0.026
Pekin	419.0	7.81	6.41	34.76	1.39	0.828	0.71	0.273
Havana, Illinois	432.0	7.18	5.96	29.17	1.69	0.695	1.02	0.21
Havana, Spoon	440.0	7.84	4.94	4.17	0.302	0.496	0.27	0.04
Browning	346.0	4.09	3.42	4.49	0.146	0.320	0.22	0,03
Pearl	388.0	5.51	4.73	18.73	0.315	0.672	0.79	0,06
Grafton, Illinois	362.0	5.61	4.65	17.50	0.247	0.455	0.59	0.044
Grafton, Mississippi	278.0	8.52	6.82	1.77	0.080	0.443	0.03	0.001

GRAPHIC CHART DRAWN FROM THE ABOVE TABLE OF AVERAGES.



EXPLANATION.

The letters on the abscissa line refer to the stations where collections were made. B=Bridgeport; L=Lockport; J=Joliet; M=Morris; O=Ottawa; LJ=LaSalle; H=Henry; PI=Peoria (station above city); PII=Peoria (station below city); PK=Pekin; HI=Havana; PIII=Pearl; G=Grafton. Each space on the abscissa line represents a distance of 15 miles, starting from Bridgeport. On the ordinate or vertical line the spaces have the following values: For chlorine (Cl) one space represents 10 parts per million, but the abscissa or base line is taken at 35. For oxygen consumption (Ox. Con.) one space represents 2½ parts per million, with the base line at 0. For free ammonia (Fr. Am.) one space represents 2½ parts per million, with the base line at 0. For albuminoid ammonia (Alb. Am.) one space represents ¼ part per million, with the base line at 0.

Soon after the opening of the drainage canal, water was collected at a number of points and submitted to examination. The results of the tests appear in the following tables:

TABLE XXXI.—*Chicago*—

Date.	Color.	Odor.	Sediment.	Temperature. Water....	Temperature. Air........	Solids. In solution.	Solids. In suspension.....	Solids. Total.....	Loss on ignition. Not filtered	Loss on ignition. Filtered...	Oxygen absorption. Not filtered	Oxygen absorption. Filtered....
1900.												
Feb. 6	None............	None........	None........	....	....	148	....	148	....	....	1.36	......
" 13	"	"	"	....	....	140	....	140	....	....	1.84	......
Mar. 6	"	"	"	....	....	162	....	162	....	....	1.28	......
" 13	"	"	"	....	....	152	....	152	22	....	1.20	......
" 20	"	"	"	....	....	144	....	144	....	....	1.52	......
" 27	"	"	"	....	....	140	....	140	16	....	1.36	......
April 3	"	"	"	....	....	142	....	142	14	....	1.84	......
" 10	"	"	"	....	....	134	....	134	22	....	1.60	......
" 17	"	"	"	....	....	142	....	142	28	....	1.76	......
" 24	"	"	"	....	....	144	....	144	16	....	1.60	......
	Averages ...	....	....	....	....	145	....	145	17	....	1.54	......

TABLE XXXII—

Date.	Color.	Odor.	Sediment.	Temperature. Water....	Temperature. Air........	Solids. In solution.	Solids. In suspension.....	Solids. Total.....	Loss on ignition. Not filtered	Loss on ignition. Filtered...	Oxygen absorption. Not filtered	Oxygen absorption. Filtered....
Mar. 6	Dark............	Bad	Dark........	....	....	440	224	694	140	72	24.96	11.68

TABLE XXXIII.—*The Drainage Canal*—

Date.	Color.	Odor.	Sediment.	Temperature. Water....	Temperature. Air........	Solids. In solution.	Solids. In suspension.....	Solids. Total.....	Loss on ignition. Not filtered	Loss on ignition. Filtered...	Oxygen absorption. Not filtered	Oxygen absorption. Filtered....
Mar. 13	Light	Unpleasant.	Little	....	....	238	22	260	58	50	9.92	6.24
" 20	Light, clear	Bad	None........	....	....	194	10	204	32	30	9.44	4.64
" 27	Light, turbid...	"	Little	....	....	204	30	234	68	66	8.96	6.72
April 3	" ...	"	None........	....	....	200	12	212	54	52	7.36	3.44
" 10	" ...	Not good ...	Little	....	....	182	42	224	40	34	6.88	4.32
" 17	Light	Bad	"	....	....	194	20	214	52	46	5.92	4.64
" 24	Light, nearly clear	"	None........	....	....	176	28	204	28	28	6.24	3.36
	Averages ...	....	....	....	....	198	23	221	47	43	7.82	4.77

City Water from Tap at 2421 Dearborn St.

Chlorine	Ammonia: Free	Ammonia: Albuminoid	Nitrogen: In nitrates	Nitrogen: In nitrites	Nitrogen by Kjeldahl Process	Colonies—per cc	Fermentation: 1-10 cc	Fermentation: 1 cc	Coagulation of Milk.	Indol produced?
1.07	0.030	0.084	None..	None..						
1 77	0.020	0.096	Trace..	"						
1.80	0.008	0.070	0 06	Trace..		1,420	None..	5	None	No.
2.10	0.020	0.066	0.05	None..		724	"	None..	Very slow	"
1.80	0.030	0.056	0.07	"		1,925	"	40	24 hours	"
2.00	0.040	0.128	Trace..	"		66	"	None..	Slow	"
2.00	0.012	0.082	None..	"		570	"	"	Very slow	"
1.80	0.014	0.090	0.06	"		115	"	"	None.	"
2.10	0.014	0.054	0 08	"		55	"	"	Very slow	"
1.80	0.016	0.086	0.05	"		320	"	"	"	"
1.82	0.020	0,081	0.037							

Bridgeport Pumping Station.

95.9	6.00	2.50	None..	0.03	9.10	540,000	20	30	Rapid	Yes

Western Avenue Bridge.

17.8	3.46	1.46	None.	None..	5.18	490,000	20	50	Rapid	Yes
10.7	3.00	0.64	0.16	0.04	3.53	483,000	15	20	"	"
14.2	1.60	1.70	None..	0.03	3.62	26,500	10	10	"	"
14.2	1.74	0.92	0.20	0.05	2.39	340,000	10	10	Very rapid	"
7.1	0.96	1.10	0.20	0.16	2.07	810,000	15	80	"	"
8.5	0.79	0.69	0.24	0.07	1.31	609,000	10	50	"	"
9.2	0.88	0.80	None..	0.02	1.33	203,000	40	10	"	"
11.7	1.78	1.04	0.11	0.05	2.78					

Table XXXIV—*Morris*—

Date.		Color.	Odor.	Sediment.	Temperature. Water.....	Temperature. Air.........	Solids. In solution.	Solids. In suspension.....	Solids. Total......	Loss on ignition. Not filtered	Loss on ignition. Filtered ...	Oxygen absorption. Not filtered	Oxygen absorption. Filtered...
1900.													
Mar.	7	Light, turbid...	Sour	Little	32°	37°	302	8	310	58	42	5.76	3.52
* "	14	Clay	Little	Heavy clay..	34	36	128	354	482	54	32	14.40	6.40
† "	21	Light	Bad	Light	32	36	208	64	272	40	26	9.60	6.16
‡ "	28	Dark	Little	Fine black..	32	34	194	36	230	48	42	9.76	7.76
Apr.	4	Light	Bad	Sandy	42	58	220	48	268	58	48	9.44	6.88
"	11	Dark	Little	Dark fine ...	40	35	242	22	264	54	52	9 28	6.56
"	18	Light	Faint	Granular ...	51	54	304	36	340	82	76	9.44	6.24
"	25	"	Bad	Little	52	64	252	24	276	36	36	6.40	5.04
		Averages ...	....	....	....	....	231	74	305	54	45	9.26	6.07

*Snow melting and river very high.
†River high.
‡River high.

Table XXXV.—*Peoria*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on ignition. Not filtered	Loss on ignition. Filtered	Oxygen absorption. Not filtered	Oxygen absorption. Filtered
Mar.	7	Light	Bad	None........	32°	42°	252	28	280	60	40	8.16	4.96
§ "	14	Clay	Not good ...	Heavy clay..	35	39	190	304	494	70	48	12.32	5.44
‖ "	21	"	Bad	"	34	44	152	144	296	62	46	15.04	8.32
"	28	Dark	"	Flocculent..	33	35	230	98	328	62	60	20.80	14.72
Apr.	5	"	"	Sandy	36	60	240	78	318	79	68	12.80	7.68
"	11	Light	Little	"	38	36	218	54	272	52	50	9.92	6.40
"	18	Dark	Very bad ...	Flocculent..	44	64	282	26	308	86	62	19.52	15.04
¶ "	25	"	"	He'vy green	58	64	392	50	442	162	114	34.88	29.28
		Averages ...	....	....	....	....	244	98	342	82	61	16.93	11.48

§River very high.
‖Water muddy from creek emptying above.
¶Kjeldahl determination gave 18.1 Mgm. of organic nitrogen per liter.

Table XXXVI.—*Havana*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on ignition. Not filtered	Loss on ignition. Filtered	Oxygen absorption. Not filtered	Oxygen absorption. Filtered
1900.													
Mar.	5	Dark	Bad	Dark	34°	26°	242	42	284	64	64	9.44	7.60
* "	12	Clay............	Good	Clay	34	38	222	138	360	54	50	8.96	5.52
† "	19	"	"	"	34	48	244	90	334	38	28	10.88	7.68
"	26	"	Little	"	36	38	164	68	232	46	28	8.00	5.20
April	2	Light	Good	"	40	46	182	14	196	30	28	7.68	5.92
"	9	Sandy	Little	Sandy	42	45	206	26	232	44	36	7.68	6.24
"	16	Yellow..........	"	"	46	60	214	26	240	52	36	7.84	6.88
"	23	Light	Good	Little	56	65	238	26	264	32	30	6.24	6.08
"	30	....	....	....	60	70	248	24	272	64	60	......	......
		Averages...	....	....	....	....	218	50	268	47	40	8.34	6.39

* Heavy snow melting; river high.
† River very high.

The Illinois River.

Chlorine	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates	Nitrogen. In nitrites	Colonies—per cc.	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
21.3	3.30	0.70	0.16	0.02	288,000	15	35	Very rapid	Yes
3.6	1.20	0.96	0.44	Trace.	244,900	50	30	"	"
9.2	3.50	6.80	1.09	0.03	3,820,000	10	100	"	"
6.4	1.54	0.70	0.72	0.04	147,000	15	85	"	"
9.2	1.44	0.65	0.16	0.34	204,000	30	50	"	"
10.0	1.35	0.55	1.00	0.02	124,000	45	100	"	"
23.4	2.85	0.55	0.72	0.02	76,000	15	50	"	"
15.6	1.85	0.65	0.40	0.03	54,000	60	60	"	"
12.3	2.13	0.69	0.57	0.06	....	....	....		

The Illinois River. (below Wesley.)

12.1	1.80	1.20	0.40	0.02	360,000	25	20	Very rapid	No
6.4	1.20	0.80	0.56	Trace.	162,000	15	25	"	Yes
5.7	4.24	1.86	None.	0.40	312,000	40	15	"	"
9.2	2.06	5.40	None.	0.02	42,000	10	25	"	"
8.5	3.54	1.66	None.	Trace.	2,752,000	40	45	"	"
5.7	0.50	0.60	2.00	0.03	9,600	35	60	"	"
11.4	3.82	3.00	None.	None.	141,500	10	20	"	"
14.2	7.30	4.10	None.	None.	589,000	20	50	"	"
9.1	3.06	2.21	0.37	0.06	....	....	....		

The Illinois River.

7.8	1.18	0.55	0.60	0.04	1,309,000	15	15	24 hours	Yes
4.3	1.00	0.43	0.88	None..	673,000	20	20	"	No
3.2	1.75	0.53	1.00	0.02	321,600	40	30	"	Yes
2.8	0.75	0.48	0.72	Trace.	147,600	None..	20	"	No
4.3	0.88	0.41	0.08	0.25	16,200	None..	5	Very rapid	"
5.0	0.74	0.43	1.20	0.02	44,400	None..	10	24 hours	Yes
5.0	0.66	0.43	2.24	0.04	870,000	None..	None..	18 "	No
7.8	0.45	0.49	1.60	0.06	198,000	30	5	Rapid	Yes
7.1	0.28	0.63	1.68	0.02	4,300	20	25	24 hours	No
5.2	0.86	0.55	1.11	0.05					

Table XXXVII—*Havana*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Oxygen Absorption.	
				Water....	Air........	In solution.	In suspension....	Total......	Not filtered	Filtered ...	Not filtered	Filtered ...
1900.												
Mar. 5	Yellow..........	Peculiar	Sandy	34°	26°	248	36	284	50	46	7.36	6.96
* " 12	Dark............	Earthy......	Very heavy clay.......	34	38	102	1338	1440	112	20	30.08	4.80
" 19	Yellow..........	Good........	Sandy	34	48	214	54	268	40	30	7.36	4.56
" 26	Clay	Little	Dark.........	36	38	208	30	238	46	32	9.12	5.52
April 2	Dark............	Earthy......	Very heavy.	40	46	176	1898	2074	178	28	50.88	5.28
" 9	"	"	Sandy	42	45	222	40	262	48	38	7 04	4.48
" 23	Light	Little	Little	56	65	296	30	326	26	26	4.80	4.32
Averages...	....	....	....	....	....	210	489	699	71	31	16.66	5.13

* Heavy snow melting; river high.

Table XXXVIII.—*Pearl*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Oxygen Absorption.	
				Water....	Air........	In solution.	In suspension.....	Total......	Not filtered	Filtered....	Not filtered	Filtered....
1900.												
*Mar. 7	Clay.............	Good........	Clay.........	58°	34°	200	568	768	58	44	11.84	5.12
† " 13	"	"	Very heavy.	44	54	176	876	1052	66	40	15.36	4.56
" 20	Light	"	Sandy.......	36	32	194	254	448	48	36	11.36	5.12
" 27	Yellow..........	"	"	46	56	190	86	276	48	44	8.80	4.32
Apr. 3	Light	Earthy......	Little........	45	65	184	66	250	58	32	7.84	4.96
" 10	"	Good........	Sandy.......	32	44	190	110	300	52	30	6.08	5.60
" 17	"	None........	"	53	62	212	60	272	44	39	7.84	5.76
" 24	"	Good........	"	60	72	224	74	298	48	44	5.12	4.96
Averages ...	....	....	....	....	....	196	262	458	53	39	9.28	5.05

* River high; heavy snow melting.
† River very high.

Table XXXIX.—*Grafton*—

1900.												
Feb. 15	Yellow..........	Good........	Clay.........	32°	36°	204	824	1028	....	....	10.24	4.88
" 19	"	"	Heavy	34	40	268	236	504	92	92	11.84	5.44
" 28	Dark	"	Clay.........	30	20	220	410	630	82	64	16.00	8.32
*Mar. 7	Clay............	"	Heavy, clay.	32	38	200	842	1042	74	28	13.12	5.04
" 14	"	Little........	"	39	42	178	436	614	68	36	11.36	5.36
" 21	Light	Good........	Very heavy.	35	40	140	704	844	76	36	13.44	4.56
" 28	Clay............	"	Clay.........	42	56	140	338	478	46	30	9.92	5.76
Apr. 4	Dark	Little........	Sandy	45	56	150	202	352	34	28	8.80	5.28
" 11	Light	None........	"	50	36	192	276	468	56	40	6.88	4.48
" 18	"	Good........	"	54	58	204	142	346	38	30	7.20	4.96
" 27	"	None........	"	60	76	228	66	294	46	38	6.40	5.36
Averages ...	....	....	....	....	....	193	407	600	61	42	10.47	5.40

* River high.

The Spoon River.

Chlorine............	Ammonia. Free	Albuminoid	Nitrogen. In nitrates.	In nitrites.	Colonies—per cc....	Fermentation. 1-10 cc. (Per cent).....	1 cc. (Per cent).....	Coagulation of Milk.	Indol produced?....
4.3	0 75	0.43	0.80	0.03	386,400	10	5	24 hours	No.....
2.1	0.60	1.60	None..	0.05	264,000	10	10	"	" ....
2.8	2.23	0.48	0.80	0.02	198,000	10	65	"	" ....
2.8	0.60	0.45	0.80	0.05	118,800	None..	None..	"	" ....
6.4	0.78	2.45	0.16	0.30	180,000	10	10	Very rapid	Yes....
8.5	0.25	0.39	1.52	0.04	31,000	None..	30	"	" ....
4 3	0.14	0.26	1.76	0.03	6,200	50	60	Slow	No.....
4.5	0.76	0.87	0.83	0.07					

The Illinois River.

Chlorine............	Ammonia. Free	Albuminoid	Nitrogen. In nitrates.	In nitrites..	Nitrogen by Kjeldahl process......	Colonies—per cc....	Fermentation. 1-10 cc. (Per cent).....	1 cc. (Per cent)....	Coagulation of milk.	Indol produced.....
4.6	0.67	0.51	1.20	0.10	......	21,000	50	30	Rapid..................	Yes....
3.6	0.39	0.72	0.92	0.01	......	158,400	20	40	Very rapid...........	No.....
2.8	0.80	0.52	1.00	0.02	......	32,450	None..	5	"	" ....
3.6	0.53	0.40	1.36	Trace..	......	8,200	15	40	24 hours	" ....
3.5	0.42	0.32	0.08	0.32	......	5,400	None..	50	"	" ....
6.4	0.40	0.35	1.36	0.02	......	4,600	"	15	"	" ....
5.0	0.23	0.28	1.76	0.03	......	5,800	"	25	"	" ....
5.0	0.21	0 48	1.80	0.05	......	30,000	40	50	Very rapid...........	Yes....
4.3	0.46	0.45	1.18	0.07	......					

The Illinois River.

6.4	0.98	1.20	1.20	0.02	2.42	....	....	....	....	....
5.7	0.86	0.82	0.80	0.03	1.71	....	....	....	....	....
3.9	0.72	0.70	0.60	0.03	1.72	21,000	None..	None..	24 hours..............	No.....
5.0	0.48	0.94	1.12	Trace..	1.72	22,200	25	10	Rapid	Yes....
4.3	0.44	0.67	1.04	"	1.35	62,000	15	25	24 hours..............	No.....
3.6	0.50	0.73	1.28	0.02	2.06	106,800	10	30	Rapid	" ....
4.3	0.48	0.53	0.80	0.03	1.50	5,400	40	60	24 hours..............	Yes....
3.5	0.49	0.40	0.04	0.20	1.06	4,700	None..	None..	Very slow............	No.....
4.3	0.23	0.37	1.60	0.03	1.91	6,200	"	80	24 hours..............	" ....
5.0	0.18	0.40	1.36	0.03	0.80	10,400	"	30	"	" ....
6.4	0.18	0.50	1.40	0.04	1.07	18,000	40	70	"	" ....
4.8	0.50	0.66	1.02	0.04	1.58					

TABLE XL.—*Averages for Spring work, 1900.*

	Total solids	Loss on ignition.		Oxygen absorption.		Chlorine............	Free ammonia	Alb. ammonia......	Nitrogen in nitrates	Nitrogen in nitrites.	Organic nitrogen Kjeldahl..........
		Not filtered	Filtered ...	Not filtered	Filtered ...						
Chicago, Lake.............	145	17	17	1.54	......	1.82	0.020	0.081	0.037	0.0	......
Bridgeport, I. & M canal ..	664	140	72	24.96	11.68	95.9	6.00	2.50	0.0	0.03	9.10
Western av., drain. canal..	221	47	43	7.82	4.77	11.7	1.78	1.04	0.11	0.05	2.78
Morris, Illinois river	305	54	45	9.26	6.07	12.3	2.13	0.69	0.57	0.06	......
Peoria, Wesley, Ill. river ..	342	82	61	16.93	11.48	9.1	3.06	2.21	0.37	0.06	......
Havana, Illinois river......	268	47	40	8.34	6.39	5.2	0.86	0.55	1.11	0.05	......
Havana, Spoon river.......	699	71	31	16.66	5.13	4.5	0.76	0.87	0.83	0.07	......
Pearl, Illinois river	458	53	39	9.28	5.05	4.3	0.46	0.45	1.18	0.07	......
Grafton, Illinois river......	600	61	42	10.47	5.40	4.8	0.50	0.66	1.02	0.04	1.58

The main work of the summer examinations began early in June, 1900, and was continued untill the end of September. Tabulated statements of the results obtained as follows.

TABEL XLI—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on Ignition. Not filtered	Loss on Ignition. Filtered	Chlorine
1900.												
June	5	None	None	None	....	....	150	....	150	24	24	2.13
″	12	″	″	″	....	....	152	....	152	24	24	2.13
″	19	″	″	″	....	....	138	....	138	16	16	2.13
″	26	″	″	″	....	....	134	....	134	14	14	2.13
July	3	″	″	″	....	....	162	....	162	20	20	2.13
″	10	″	″	″	....	....	136	....	136	8	8	2.13
″	17	″	″	″	....	....	130	....	130	8	8	2.48
″	24	″	″	″	....	....	140	....	140	14	14	2.13
″	31	″	″	″	....	....	140	....	140	22	22	2.13
Aug.	7	″	″	″	....	....	140	....	140	22	22	2.13
″	14	″	″	″	....	....	146	....	146	24	24	2.13
″	21	″	″	″	....	....	134	....	134	10	10	2.31
″	29	″	″	″	....	....	140	....	140	16	16	2 13
Sept.	4	″	″	″	....	....	148	....	148	14	14	2.13
		Averages....	....	....	....	....	148	....	148	17	17	2.17

TABLE XLII.—*Bridgeport*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on Ignition. Not filtered	Loss on Ignition. Filtered	Chlorine
1900.												
July	29	Light, turbid	Bad	Little	....	....	494	42	536	72	72	127.8
″	31	Dark	″	Black	....	....	440	24	464	82	72	113.6
Aug.	2	″	″	″	....	....	244	54	298	48	40	39.0
″	7	Light	″	″	....	....	336	40	376	72	52	78.1
″	10	Dark	″	″	....	....	290	22	312	64	42	49.7
″	14	″	″	″	....	....	520	72	592	90	46	177.5
* ″	17	″	″	Blk. floc'l'nt	....	....	474	112	586	92	42	127.8
″	21	″	″	Brown	....	....	276	42	318	62	36	39.0
″	24	″	″	Black	....	....	544	140	684	136	74	191.7
″	29	″	Very bad	″	....	....	534	48	582	86	70	14.9
″	31	″	Bad	″	....	....	526	38	564	60	56	134.9
Sept.	4	″	Little	″	....	....	164	16	180	38	36	10.7
″	11	″	Bad	Little	....	....	234	22	256	56	44	28.4
″	18	Light, turbid	″	″	....	....	426	150	576	100	60	166.8
″	25	Dark	″	Black	....	....	244	144	388	86	68	46.1
		Averages....	....	....	....	....	383	64	447	76	54	89.7

* Aug. 17. Tug passed before collection was made.

Chicago City Water.

Oxygen Absorbed. Not filtered	Oxygen Absorbed. Filtered....	Ammonia. Free........	Ammonia. Albuminoid	Nitrogen. In nitrates.	Nitrogen. In nitrites..	Colonies—per cc....	Fermentation. 1-10 cc.......	Fermentation. 1 cc........	Coagulation of Milk.	Indol produced.....
2.00	......	0.014	0.028	None......	None......	450	None..	None..	None.................	No.
1.44	......	0.028	0 100	"	"	170	" ..	" ..	"	"
1.60	......	0.016	0.076	"	"	100	" ..	" ..	"	"
2.64	......	0.028	0.112	"	"	72	" ..	" ..	"	"
1.76	......	0.016	0.130	0.10	"	44	" ..	" ..	"	"
1.20	......	0.018	0.084	None......	"	190	" ..	20	48 hours..............	"
2.00	......	0.020	0.106	"	"	370	" ..	None..	None.................	"
1.52	......	C.014	0.096	Faint tr'ce	"	105	" ..	" ..	"	"
2.64	......	0.016	0.096	None......	"	175	" ..	" ..	"	"
2.72	......	0.012	0.110	0.03	"	620	" ..	" ..	"	"
2.00	......	0.010	0.074	None......	Indication	820	" ..	" ..	"	"
1.60	......	0.010	0.112	"	"	95	" ..	" ..	"	"
1.68	......	0.010	0.120	0.06	"	43	" ..	5	Slow..................	"
2.24	......	0.010	0.080	Trace	None......	45	" ..	None..	None.................	"
2.93	......	0.016	0.094							

Illinois and Michigan Canal.

Oxygen Absorbed. Not filtered	Oxygen Absorbed. Filtered ...	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates.	Nitrogen. In nitrites..	Nitrogen by Kjeldahl process........	Colonies—per cc	Fermentation. 1-10cc. (Per cent).....	Fermentation. 1 cc. (Per cent).....	Coagulation of Milk.	Indol produced? ....
15.36	7.54	13.30	1.30	None..	None..	13.58	....	......	......	....	......
12.96	5.92	13.00	2.80	"	0.03	13.00	720,000	15	15	....	No...
12.78	9.60	5.50	2.20	0.60	2.00	6.83	872,000	25	20	Very rapid..	" ..
15.36	5.76	10 50	4.50	None..	0.08	10.90	438,000	15	15	" ..	" ..
13.12	12.48	10.00	2.20	"	0.03	10.50	310,000	20	25	12 hours	" ..
20.80	8.80	21.00	3.50	"	0.10	19.90	2,460,000	20	25	Very rapid..	" ..
25.28	11.20	17.20	3.00	"	0.01	18.76	1,838,000	20	10	15 hours	" ..
15.68	9.76	7.50	2.00	"	None..	8.47	306,000	20	20	Very rapid..	" ..
26.88	21.12	23.50	2.00	"	"	23.29	884,000	20	25	" ..	" ..
19.20	8.96	22.80	2.50	"	0.20	20.80	1,518,000	15	25	" ..	Yes..
15.04	10.24	25.50	3.80	"	None..	23.90	632,000	15	None..	" ..	" ..
4.64	4.00	2.50	1.30	1.00	0.08	3.37	330,000	30	40	Rapid........	No...
7.52	4.00	5.80	1.60	0.36	0.16	6.75	1,344,000	20	30	"	" ..
17.60	8.00	35.50	3.00	None..	Trace..	....	780,000	10	5	"	" ..
22.40	9.28	......	......	"	None..	....	Liquifi'd	15	10	"	" ..
16.31	9.11	15.26	2.55	0.13	0.17	13.85					

Table XLIII—

Date.		Color.	Odor.	Sediment.	Temperature. Water....	Temperature. Air....	Solids. In solution.	Solids. In suspension....	Solids. Total.....	Loss on Ignition. Not filtered	Loss on Ignition. Filtered...	Chlorine..........
1900.												
June	5	Light............	Bad.........	Little.......	....	....	168	46	214	30	26	7.1
"	12	Dark............	".........	".......	....	....	194	26	220	34	26	16.3
"	19	Light............	".........	".......	....	....	162	18	180	42	42	7.1
"	26	Light turbid....	".........	".......	....	....	160	30	190	48	38	7.8
July	3	Li'ht, n'rly clear	".........	None.......	....	....	212	10	222	68	68	13.5
"	10	Light............	".........	Little.......	....	....	186	28	214	38	36	9.2
"	17	Light turbid....	".........	".......	....	....	168	14	182	36	36	8.5
† "	24	"	".........	".......	....	....	200	18	218	34	32	9.2
"	31	"	".........	".......	....	....	164	28	192	58	48	9.9
Aug.	7	Light............	".........	".......	....	....	168	28	196	52	34	8.5
"	14	Dark............	".........	Black.......	....	....	186	34	220	40	40	6.4
"	21	"	".........	".......	....	....	194	22	216	48	32	11.4
"	29	Dark turbid.....	".........	".......	....	....	180	36	216	52	38	8.5
Sept.	4	Dark............	Little.......	Dark.......	....	....	150	10	160	38	34	5.7
		Averages....	....	....	....	....	178	25	203	44	38	9.2

* July 24. Rain at time of collection.

Table XLIV.—*Lockport*—

Date.		Color.	Odor.	Sediment.	Temperature. Water....	Temperature. Air....	Solids. In solution.	Solids. In suspension....	Solids. Total.....	Loss on Ignition. Not filtered	Loss on Ignition. Filtered...	Chlorine..........
1900.												
June	4	Light, slightly turbid..........	Bad.........	None........	62°	78°	186	12	198	28	26	11.4
"	11	Light, clear......	".........	Little........	50	71	212	12	224	38	36	13.5
July	2	Light, n'rly clear	".........	None........	69	90	200	40	240	64	36	10.6
"	9	Light............	".........	Granular ...	....	....	246	26	272	58	46	22.7
"	23	Light, n'rly clear	".........	None........	....	86	164	8	172	28	22	8.5
"	30	Light............	".........	"........	....	84	182	16	198	52	46	10.6
Aug.	6	"	".........	Very fine ...	....	90	182	14	196	38	34	11.4
* "	13	"	".........	None........	....	92	166	18	184	28	22	11.4
"	20	Dark............	".........	Granular ...	72	90	192	58	250	52	30	16.3
"	27	Light............	".........	Flocculent..	76	90	218	12	230	46	40	17.0
Sept.	4	Light, turbid....	Little.......	None........	74	90	170	....	170	36	36	5.7
		Averages....	....	....	....	....	193	19	212	42	34	12.6

* Aug. 13. Arrived late and was not iced.

Western Avenue Bridge—Drainage Canal.

Oxygen absorbed.		Ammonia.		Nitrogen.		Nitrogen by Kjeldahl process........	Colonies—per cc....	Fermentation.		Coagulation of Milk.	Indol produced?....
Not filtered	Filtered....	Free........	Albuminoid	In nitrates.	In nitrites..			1-10 cc. (Per cent).....	1 cc. (Per cent).....		
5.60	4.88	1.38	0.70	None..	0.03	2.45	162,000	......	50	....	Yes..
9.92	5.44	1.50	1.50	None..	0.01	2.55	310,000	20	30	Very rapid..	" ..
4.96	4.08	1.15	0.68	0.12	0.01	2.27	1,656,000	None	None..	" ..	No...
5.60	4.72	0.96	0.70	None..	0.02	2.43	Liqu'fied	10	25	Rapid	" ..
6.48	5.60	1.00	0.90	0.40	0.20	2.80	890,000	15	15	20 hours	" ..
8.00	4.00	1.57	0.69	None..	0.32	2 61	170,000	10	10	12 hours	" ..
7.20	4.32	1.04	0.90	None..	0.04	2.66	300,000	5	40	Very rapid..	Yes..
5.68	5.20	3.10	1.42	None..	0.02	4.19	326,000	10	10	" ..	" ..
5.76	3.92	1.00	0.82	None..	0.08	1.72	Liqu'fied	15	15	" ..	No...
5.12	4.32	1.00	1.02	0.60	0.03	2.14	"	40	5	" ..	" ..
6.08	3.20	1.40	1.10	None..	0.04	2.47	960,000	20	20	Rapid	" ..
7.52	4.88	1.82	0.94	None..	0 64	3.14	462,000	10	10	Very rapid..	" ..
5.52	4.16	1.00	1.20	0.12	0.04	2.80	1,140,000	10	10	15 hours	" ..
4.48	3.20	0.80	0.80	0.52	0.04	1.81	480,000	30	30	24 hours	Yes..
6.28	4.42	1.34	0.95	0.12	0.11	2.58					

Canal.

Oxygen Absorbed.		Ammonia.		Nitrogen.		Colonies—per cc....	Fermentation.		Coagulation of Milk.	Indol produced? ...
Not filtered	Filtered....	Free	Albuminoid	In nitrates.	In nitrites.		1-10 cc. (Per cent)....	1 cc. (Per cent)....		
4.96	4.08	1.65	0.57	None....	Trace....	165,000	None..	50	12 hours...........	Yes..
4.88	4.32	2.40	0.74	"	0.01	653,000	30	50	Very rapid.........	" ..
4.56	4.48	1.55	0.55	0.02	0.02	502,500	40	40	"	No...
7.20	5.04	2.90	0.64	None....	Trace....	104,000	55	35	"	" ..
4.80	3.12	1.50	0.64	"	"	82,000	10	80	"	" ..
4.00	3.76	1.90	0.94	"	"	840,000	35	40	Rapid	Yes..
4.56	3.92	2.20	1.30	"	0.04	1,860,000	35	45	Very rapid.........	" ..
4.24	3.36	2.24	0.34	"	None....	....	....	....	....	......
8.00	5.60	2.16	1.10	"	0.40	660,000	30	50	Rapid	No...
6.08	5.44	3.56	0.90	"	0.20	720,000	20	20	"	" ..
4.96	4.56	1.70	0.36	"	Trace....	288,000	50	40	"	" ..
5.29	4.34	2.16	0.76	....	0.06					

TABLE XLV.—

Date.	Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on ignition. Not filtered	Loss on ignition. Filtered	Chlorine
1900.											
June 4	Yellow	Bad	Light	60°	72°	224	16	240	52	52	24.8
" 11	"	"	Little	70	70	276	32	308	60	56	32.7
" 18	"	Faintly disagreeable	Flocculent	72	76	264	40	304	80	68	38.3
" 25	Dark yellow	Not good	Rusty	72	80	264	58	322	74	48	35.5
July 2	Light	Bad	Yellow	74	86	208	18	226	58	52	17.0
" 9	"	Not good	Granular	74	80	282	38	320	58	40	43.3
" 16	"	"	"	76	84	232	24	256	52	44	29.8
" 23	"	Bad	Yellow	78	86	232	58	290	50	38	31.2
" 30	Yellow	"	Granular	76	84	262	30	292	52	46	35.5
Aug. 6	Light	"	Flocculent	78	90	244	42	286	38	20	29.1
" 13	"	"	"	72	86	236	48	284	48	34	30.5
" 20	Yellow	"	Granular	78	90	256	34	290	46	40	39.0
" 27	Dark	"	Flocculent	76	80	258	54	312	64	38	34.0
Sept. 3	Yellow	Little	Yellow	76	80	232	14	246	42	40	27.0
Oct. 1	Dark	Bad	Dark	64	68	208	20	228	40	40	24.1
	Averages					245	35	280	54	44	31.4

TABLE XLVI– *Morris*—

1900											
June 4	Light	Bad	Dark, flocculent	60°	70°	220	44	264	40	38	14.9
" 11	"	"	Dark, flocculent	65	86	292	10	302	68	64	24.1
" 18	"	"	Flocculent	55	70	224	32	256	34	24	17.0
" 25	"	Not good	Little	71	80	208	14	222	40	36	16.3
July 2	"	Bad	"	64	84	226	12	238	44	42	22.7
" 9	"	"	Flocculent	65	78	220	24	244	64	60	22 7
" 16	Light, turbid	Faintly disagreeable.	Very little	70	85	210	14	224	48	46	20.6
" 23	Light	Bad	Very fine	72	90	218	18	236	36	36	17.8
" 30	"	Not good	Flocculent	70	90	216	42	258	56	40	17.7
Aug. 6	"	"	Sandy	80	92	198	30	228	20	18	15.6
* " 13	Yellow	Bad	Dark, sandy	72	75	220	14	224	36	34	21.3
" 20	Light	Earthy	Fine	80	85	238	20	258	46	34	10.7
" 27	Dark	Bad	Gray	78	98	242	28	270	54	46	17.0
Sept. 4	Light	"	Little	76	74	208	52	260	40	38	14.2
Oct. 3	Dark	"	Yellow	60	65	192	84	276	34	26	14.9
	Averages			....	....	222	29	251	44	39	17.8

* Heavy winds

Joliet.

Oxygen Absorbed		Ammonia.		Nitrogen.		Colonies—per cc	Fermentation.		Coagulation of Milk.	Indol produced?....
Not filtered	Filtered....	Free.......	Albuminoid	In nitrates.	In nitrites..		1-10cc	1 cc.		
6.24	5.20	4.47	0.71	None....	0.01	264,000	50	50	....	Yes .
6.72	4.64	5.46	0.94	"	0.03	248,000	80	30	Very rapid.........	"
5.52	3.52	6.40	0.80	"	0.03	35,000	None..	30	Rapid	"
5.96	3.36	7.10	0.92	"	0.04	Liquifi'd	" ..	None..	Very rapid.........	No...
6.64	3.84	3.06	1.18	0.28	0.08	650,000	25	30	Rapid	" ..
6.64	4.88	5 20	0.94	None....	0.04	173,000	10	10	Very rapid.........	" ..
7.84	3.92	3.80	0.56	"	0.04	37,000	80	50	Rapid	Yes .
8.00	4.00	4.20	1.16	"	0.03	4,500	15	25	"	No...
7.20	5.92	5.30	0.44	"	0.04	125,000	10	20	Very rapid.........	" ..
5.84	4.80	4.20	1.00	"	0.40	845,000	20	10	"	" ..
6.80	4.08	3.98	0.90	"	0.06	616,000	25	50	12 hours	Yes .
6.40	4.80	4.60	0.41	"	0.32	152,000	60	40	Very rapid.........	"
7.36	5.44	4.80	1.40	Trace....	0.04	488,000	10	25	15 hours............	No...
5.92	4.96	3.40	0.70	None....	0.08	896,000	20	10	24 hours............	" ..
8.48	4.40	4.00	0.66	"	0.08	Liquifi'd	30	30	16 hours............	" ..
6.97	4.52	4.66	0.85	0.02	0.09					

The Illinois River.

8.80	5.76	1.70	0.49	0.48	0.50	18,000	10	25	24 hours............	No ..
7.36	5.12	3.25	0.65	0.28	0.20	217,600	50	60	14 "	Yes..
5.44	3.92	2.93	0.50	0.16	0.16	45,200	None..	None..	Very rapid.........	No ..
5.60	3.60	4.20	0.86	None....	0.20	Liquef'd	None..	None..	24 hours............	" ..
6.72	4.32	2.25	0.45	0.32	0.32	19,400	20	20	Slow	" ..
4.64	3.60	3.45	0.37	None....	0.24	41,000	50	25	Very rapid.........	Yes..
4 80	4.48	2.76	0.70	None....	0.20	2,000	30	90	" "	No ..
6.00	4 56	1.70	1.10	0.20	0.14	2,000	50	35	24 hours............	Yes..
6.48	4.24	3.10	0.70	0.20	0.16	17,500	35	40	Rapid	No ..
5.76	4.40	2.80	0.80	0.12	0.80	11 000	15	25	24 hours............	" ..
6.64	4.48	2.40	0.46	None...	0.32	27,000	50	40	15 "	Yes..
6.00	5.52	1.50	0.60	None....	0.48	18,500	None ..	30	Slow	No...
7.20	4.40	4.40	0.60	Trace ...	0.20	19,500	60	90	Rapid	" ..
7.76	5.92	2.70	0.70	0.80	0.16	650,000	10	40	24 hours............	" ..
6 80	5.60	3.40	0.50	None....	Trace ...	Liquef'd	10	None..	"	" ..
6.40	4.66	2.84	0.63	0.17	0.27					

Table XLVII—*Ottawa*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on Ignition. Not filtered	Loss on Ignition. Filtered	Chlorine
1900.												
June	4	Dark	Bad	Dark	72°	84°	236	86	322	48	48	11.4
"	11	Yellow	Earthy	Little	76	82	332	16	348	102	96	17.8
"	18	Light	"	"	72	77	264	40	304	42	32	17.7
"	26	"	Good	"	78	90	274	42	316	96	74	22.0
July	2	"	Earthy	"	78	92	236	8	244	52	44	16.3
"	9	"	Good	Fine	75	80	226	14	240	54	50	19.2
"	17	"	Earthy	None	76	75	208	6	214	28	26	15.6
"	23	"	"	Little	78	90	218	4	222	36	34	17.8
"	30	Dark turbid	Little	Fine dark	76	84	240	80	320	54	52	15.6
Aug.	6	Slightly yellow	Faintly disagreeable.	Sandy	96	80	222	10	232	32	32	14.9
* "	13	Light	Faintly disagreeable.	Fine	78	90	218	22	240	42	32	18.5
"	20	Yellow	Good	Sandy	80	94	222	30	252	40	24	17.0
† "	27	Dark	Not good	Fine	78	85	246	42	288	48	48	23.4
Sept.	4	Light	Faint	Little	76	85	224	24	248	52	48	14.2
Oct.	16	"	Good	Very little	62	56	206	2	208	28	26	16.3
		Averages					238	28	266	50	44	17.2

*Aug. 13, heavy rains.
†Aug. 27, river high and muddy.

Table XLVIII—*Ottawa*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on Ignition. Not filtered	Loss on Ignition. Filtered	Chlorine
1900.												
July	30	Light'	Good	Little	‡76°	84°	288	12	300	78	78	6.4
Aug.	6	Very light	None	Very fine	96	80	298	22	320	62	62	3.5
‡ "	13	Light yellow	Earthy	Fine sandy	78	90	290	26	316	88	78	5.0
		Averages					292	20	312	79	72	4.9

‡Aug. 13, heavy rains.

Table XLIX.—*La Salle*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on Ignition. Not filtered	Loss on Ignition. Filtered	Chlorine
1900.												
June	4	Light	Little	Sandy	76°	86°	232	54	286	40	32	10.6
* "	11	"	"	Little	76	86	284	30	314	40	40	19.2
"	18	"	Faint	"	75	74	260	24	284	72	68	17.8
"	25	"	"	Fine	78	90	236	14	250	42	40	18.5
July	2	"	Little	Little	80	80	244	16	260	36	28	17.0
"	9	"	"	Fine	80	82	232	22	254	42	36	19.9
"	17	"	Good	Sandy	78	72	228	22	250	32	28	18.5
"	23	"	Little	Little	79	82	218	22	240	34	34	18.5
"	30	Light, turbid	"	Sandy	80	80	252	82	334	80	72	14.2
Aug.	6	Light	"	Granular	84	80	282	38	320	52	52	14.9
"	13	Light, turbid	Faintly disagreeable.	Fine	82	82	224	16	240	52	52	17.7
"	20	Yellow	Good	Little	82	82	236	20	256	42	40	16.3
"	27	"	"	Sandy	80	80	246	16	262	38	32	12.8
Sept.	3	Light	"	Fine	82	84	370	6	376	76	74	8.5
Oct.	3	"	"	Little	70	80	230	12	242	40	38	13.5
		Averages					252	26	278	48	44	15.8

*June 11 sample delayed.

The Illinois River.

Oxygen Absorbed.		Ammonia.		Nitrogen.		Nitrogen by Kjeldahl process......	Colonies—per cc....	Fermentation.		Coagulation of Milk.	Indol produced?.....
Not filtered	Filtered....	Free........	Albuminoid	In nitrates.	In nitrites..			1-10 cc......	1 cc..........		
11.04	5.36	1.03	0.65	1.60	0.25	....	6,500	20	None..	20 hours	Yes .
6.64	6.00	0.60	0.58	1.60	0.28	....	18,800	15	90	14 hours	No ..
5.28	4.40	1.58	0.42	0.48	0.20	....	127,200	None	None..	24 hours	" ..
5.60	5.44	1.30	0.41	1.20	0.44	....	28,000	10	40	Rapid	" ..
4.88	4.56	0.40	0.34	1.40	0.32	....	33,500	None	50	Very slow...	" ..
5.04	4.16	1.02	0.27	0.88	0.80	....	3,000	70	20	12 hours	" ..
5.04	4.16	0.30	0.28	0.40	0.32	....	5,500	10	10	24 hours	" ..
5.36	4.56	0.35	0.34	0.88	0.20	....	2,500	30	25	Slow..........	" ..
7.20	6.08	0.90	0.65	1.20	0.40	....	25,000	26	60	24 hours	" ..
6.48	4.88	0.78	0.38	1.20	0.80	....	14,000	15	30	Very rapid..	......
4.88	4.08	1.05	0.33	Trace..	0.32	....	64,000	50	50	Rapid	Yes .
5.20	4.96	0.85	0.42	None..	0.64	....	19,500	......	70	24 hours	No ..
5.76	5.36	0.79	0.25	0.80	0.32	....	25,500	10	30	24 hours	" ..
6.64	6.40	0.56	0.30	1.12	0.20	....	3,500	35	30	24 hours	" ..
5.12	5.04	0.72	0.30	1.08	0.12	....	....	......	....	....	......
5.94	5.03	0.81	0.39	0.92	0.37	....					

The Fox River.

6.96	6.24	0.09	0.52	None..	None..	....	2,232,000	None	60	Slow..........	No ..
6.22	5.84	0.15	0.52	"	0.02	1.27	36,000	5	10	Very slow...	" ..
7.04	6.88	0.10	0.47	"	0.04	1.23	6,500	70	10	24 hours	" ..
6.77	6.32	0.11	0.50	....	0.02	1.25					

The Illinois River.

6.32	5.68	0.63	0.33	0.80	0.25	....	16,000	50	50	20 hours	Yes..
6.56	6.48	0.80	0.50	1.20	0.50	....	41,600	30	50	Rapid........	" ..
5.28	4.08	1.50	0.45	0.80	0.20	....	72,800	60	None..	24 hours	No ..
5.44	4.32	1.06	0.41	0.92	0.12	....	150,000	None	" ..	"	" ..
5.04	4.00	0.60	0.27	1.60	0.32	....	105,000	"	15	"	" ..
5.04	4.16	0.89	0.25	0.56	0.40	....	3,500	30	60	12 hours.....	" ..
4.72	4.32	0.25	0.40	0.56	0.28	....	4,000	25	40	Rapid........	" ..
4.96	4.08	0.14	0.48	1.00	0.20	....	2,000	70	40	"	" ..
7.44	5.20	0.75	0.45	0.80	0.24	....	2,000	35	50	"	Yes..
5.68	4.80	0.19	0.35	1.00	0.28	....	1,800	40	40	"	" ..
4.56	4.24	0.18	0.33	Trace..	0.24	....	8,000	70	50	"	No ..
5.60	4.96	0.10	0.35	0.40	0.14	....	13,200	50	30	20 hours.....	" ..
5.68	5.52	0.43	0.38	0.80	0.32	....	72,000	25	35	Rapid........	" ..
4.96	4.72	0.10	0.20	0.52	0.12	....	5,500	50	40	20 hours.....	Yes..
6.72	5.84	0.64	0.32	0.56	0.12	....	....	......	....	....	......
5.60	4.83	0.55	0.36	0.77	0.25						

Table L.—*LaSalle*—

Date.		Color.	Odor.	Sediment.	Temperature. Water.	Temperature. Air.	Solids. In solution.	Solids. In suspension.	Solids. Total.	Loss on Ignition. Not filtered.	Loss on Ignition. Filtered.	Chlorine.
Aug.	20	Clay	Earthy	Clay	84°	82°	270	82	352	76	48	5.0
"	27	Light, turbid	Little	Sandy	82	80	218	36	254	58	40	7.8
Sept.	3	Yellow	Good	Fine	84	84	226	18	244	56	56	15.6
		Averages			....	....	238	45	283	63	48	9.5

Table LI.—*Henry*—

Date.		Color.	Odor.	Sediment.	Temperature. Water.	Temperature. Air.	Solids. In solution.	Solids. In suspension.	Solids. Total.	Loss on Ignition. Not filtered.	Loss on Ignition. Filtered.	Chlorine.
1900.												
June	7	Light	Earthy	Little	74°	84°	236	36	272	20	20	12.8
"	14	"	Good	"	74	78	286	48	334	42	38	17.0
"	19	Yellow	None	Dark	73	70	276	48	324	78	78	14.2
"	26	Light	Little	Little	80	86	246	30	276	36	32	16.3
July	3	Dark	Not good	"	84	96	236	50	286	50	40	14.9
"	10	Light	Little	Fine	80	74	262	62	324	58	40	32.7
"	17	"	None	"	80	72	240	42	282	52	38	19.2
* "	24	"	Little	Little	80	76	220	26	246	48	40	16.3
"	31	Yellow	Good	None	82	86	296	....	296	70	70	15.6
Aug.	7	"	Little	Dark	86	96	244	16	260	52	44	14.9
† "	14	Light, turbid	Fair	Little	82	76	234	46	280	52	42	17.0
‡ "	21	Light	Good	"	82	86	242	34	276	66	50	18.5
"	28	"	"	Sandy	80	86	272	8	280	40	38	16.3
Sept.	4	Dark, turbid	"	"	80	84	226	42	268	64	50	13.5
Oct.	1	Light yellow	"	"	66	80	196	42	238	44	40	14.2
		Averages			....	....	248	35	283	51	44	16.9

* July 24, rain.
† August 14, rain.
‡ August 21, rain.

The Vermilion River.

Oxygen Absorbed.		Ammonia.		Nitrogen.		Nitrogen by Kjeldahl process..........	Colonies—per cc......	Fermentation.		Coagulation of Milk.	Indol produced? ......
Not filtered..	Filtered.....	Free........	Albuminoid..	In nitrates...	In nitrites...			1-10 cc........	1 cc...........		
6.16	4.64	0.06	0.38	0.16	0.12	1.12	22,000	25	50	Very slow...	No ..
5.12	4.64	0.07	0.27	0.32	0.04	1.13	25,500	25	40	20 hours.....	Yes.,
6.40	6.40	0.22	0.31	0.80	0.16	1.66	4,500	20	10	Slow.........	No ..
5.89	5.23	0.12	0.32	0.43	0.10	1.30					

The Illinois River.

Oxygen Absorbed.		Ammonia.		Nitrogen.		Colonies—per cc......	Fermenta t.on.		Coagulation of Milk.	Indol produced? ......
Not filtered..	Filtered.....	Free	Albuminoid..	In nitrates...	In nitrites...		1-10 cc........	1 cc...........		
5.76	4.72	0.55	0.40	1.28	0.20	5,400	None..	100	Very slow..........	No ..
6.56	5.28	0.23	0.43	1.60	0.24	6,000	20	40	24 hours............	"
9.28	5.20	0.28	1.05	0.92	0.14	*72,000	None..	None..	"	"
5.28	4.72	0.84	0.36	1.40	0.20	13,200	" ..	10	Slow	"
5.12	4.56	0.20	0.33	1.44	0.20	7,230	50	40	Rapid	"
6.00	4.80	0.94	0.48	0.72	0.32	202,500	10	5	12 hours............	"
5.92	4.40	0.28	0.39	0.40	0.20	500	None..	30	Slow	"
4.96	4.80	0.38	0.40	1.00	0.24	2,000	" ..	10	24 hours............	"
6.56	5.68	0.35	0.38	0.88	0.28	Liquifi'd	70	90	"	"
5.52	5.36	0.13	0.43	0.88	0.20	"	30	25	15 hours............	"
5.92	4.08	0.30	0.29	0.60	0.24	1,000	50	50	24 hours............	Yes .
5.12	4.80	0.71	0.30	2.00	0.04	*22,000	25	50	Very slow..........	No ..
5.52	5.28	0.25	0.26	0.88	0.24	6,500	40	50	24 hours............	Yes .
5.76	5.12	0.15	0.30	1.12	0.32	8,000	5	15	20 hours............	No ..
4.56	4.08	0.56	0.27	0.80	0.20	Liquifi'd	15	20	Slow	"
5 86	4.86	0.41	0.40	1.06	0.22					

* No ice used.

Table LII.—*Peoria, Narrows*—

Date.	Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chlorine
				Water	Air	In solution	In suspension	Total	Not filtered	Filtered	
1900.											
June 7	Clear, yellow	None	Flocculent	....	....	296	46	342	36	34	9.2
" 14	Light	Faint	Fine	....	....	238	34	272	62	46	8.5
" 21	"	Good	Little	72°	72°	306	2	308	84	82	15.6
" 26	"	"	Fine	80	88	256	22	278	56	56	15.6
July 10	"	Little	"	78	76	232	32	264	52	32	15.6
" 17	Light, turbid	"	None	79	78	256	28	284	72	68	22.7
" 24	Light	Good	Very little	80	78	230	20	250	30	30	17.8
" 31	"	"	None	81	96	234	8	242	24	16	18.5
Aug. 7	"	None	"	84	94	232	....	232	48	48	12.0
" 14	"	Good	Fine	81	85	238	24	262	62	50	17.0
" 21	"	"	None	84	98	216	20	236	36	36	18.5
" 28	Light, clear	"	Little	82	86	232	12	244	52	40	14.9
Oct. 9	Light	"	Sandy	66	68	212	20	232	28	18	16.3
	Averages	....	....	....	...	244	21	265	49	43	15.5

Table LIII.—*Peoria, Wesley*—

Date.	Color.	Odor.	Sediment.	Water	Air	In solution	In suspension	Total	Not filtered	Filtered	Chlorine
1900.											
May 30	Very dark	Faint	Much	70°	80°	286	490	776	94	60	8.5
June 7	Light, clear	"	Very little	74	80	266	28	294	60	60	14.9
" 14	Dark	Bad	Little	70	84	298	56	354	96	42	17.0
" 19	Light	Good	Sandy	70	86	316	24	340	92	76	17.0
" 26	"	Faint	Little	73	84	254	50	304	68	64	14.9
July 3	Dark	Little	"	75	89	242	30	272	58	40	13.5
" 10	Light	"	Fine	80	80	250	52	302	48	44	15.6
" 17	Dark	Bad	Black	77	70	328	64	392	84	84	24.8
" 24	Yellow	Good	Fine	78	78	244	124	368	46	40	18.5
" 31	Light	Little	Granular	80	88	240	18	258	38	38	15.6
Aug. 7	Yellow	Not good	Flocculent	82	90	208	20	228	48	48	17.8
" 14	Dark	Earthy	Clay	80	76	224	384	608	48	26	15.6
" 21	"	Very bad	Fine black	84	90	254	50	304	78	58	9.9
" 28	Light	Not good	Fine	81	84	238	32	270	38	36	16.3
Sept. 4	Dark	"	Dark	80	74	252	102	354	74	48	15.6
Oct. 10	Dark and turbid	Bad	Flocculent	65	80	318	26	344	88	74	22.7
	Averages *	....	....	....	....	262	71	333	65	52	16.6

* Excluding May 30.

The Illinois River.

Oxygen Absorbed.		Ammonia.		Nitrogen.		Colonies—per cc......	Fermentation.		Coagulation of Milk.	Indol produced?......
Not filtered..	Filtered......	Free.........	Albuminoid.	In nitrates...	In nitrites...		1 cc. (Per cent)......	1-10 cc. (Per cent)......		
5.44	5.44	0.35	0.48	1.40	0.10	20,000	None..	None..	Slow...............	No...
5.52	4.64	0.22	0.28	1.40	0.06	72,000	"	90	24 hours...........	" ..
5.28	4.80	0.08	0.36	1.80	0.10	....	....	....	....	......
5.52	4.48	0.56	0.38	1.60	0.16	35,000	None..	None..	Very rapid.........	No...
4.80	4.56	0.15	0.31	0.68	0.10	2,000	35	"	12 hours...........	" ..
4.80	4.48	0.24	0.37	0.56	0.24	90,000	10	40	Rapid	" ..
4.96	4.24	0.24	0.34	0.80	0.08	51,500	85	50	24 hours...........	" ..
4.24	4.24	0.14	0.28	0.96	0.08	180,000	20	10	Very slow	" ..
4.88	4.32	0.20	0.28	0.72	0.16	7,000	None..	70	24 hours...........	" ..
4.32	3.92	0.16	0.28	0.40	0.20	2,500	5	10	Rapid	" ..
4.72	4.32	0.27	0.42	0.20	0.12	7,500	50	50	Very slow..........	Yes..
4.64	4.48	0.12	0.42	0.72	0.12	472,500	None..	15	24 hours...........	No...
6.56	4.96	0.08	0.30	1.08	0.10	....	....	....	....	......
5.05	4.53	0.21	0.34	0.95	0.12					

The Illinois River.

16.00	6.08	0,75	0.98	0.56	0.06	51,100	10	10	24 hours...........	Yes..
7.04	5.12	1.22	0.80	1.00	0.12	23,500	50	40	Rapid	"
16.64	9.92	3.00	3.00	None....	None....	3,180,000	None..	None..	Very rapid.........	No...
6.64	4.88	1.00	0.54	1.08	0.12	238,000	" ..	" ..	"	" ..
5.36	4.64	1.14	0.80	1.08	0.16	230.000	25	10	"	" ..
5.20	4.56	0.38	0.76	2.00	0.20	215,000	10	10	Rapid	" ..
6.08	3.52	0.40	0.76	0.48	0.12	126,000	5	40	12 hours...........	" ..
18.56	6.72	1.88	2.30	None....	None....	150,000	5	5	Rapid	" ..
6.24	4 48	0.60	0.50	0.80	0.08	32,000	None..	None..	"	" ..
6.16	4.48	0.70	0.50	0.92	0.12	420,000	20	10	Very rapid.........	" ..
7.12	6.80	0.86	0.92	0.72	0.20	2,729,000	5	20	Rapid	" ..
10.24	4.16	0.46	0.60	0.36	0.12	218,000	5	10	Very rapid.........	" ..
15.20	7.36	4.50	2.64	None....	0.02	About 24,000,000	10	15	15 hours...........	" ..
5.44	5.04	0.56	0.52	1.00	0.12	236,000	15	10	Very rapid.........	" ..
10.32	8.16	2.10	1.36	1.36	0.24	8,352,000	40	10	"	" ..
22.40	19.04	5.50	4.10	None....	None....					
9.91	6.59	1.62	1.34	0.72	0.11					

TABLE LIV.—*Pekin—*

Date.	Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on Ignition. Not filtered	Loss on Ignition. Filtered	Chlorine
1900.											
May 30	D'rk, very turbid	Little	Light col'r'd	70°	80°	276	480	756	88	56	9.2
June 6	Light	Earthy	Sandy	76	96	260	80	340	54	38	14.9
* " 13	"	"	Fine	73	78	260	60	320	38	36	11.4
" 20	"	"	Sandy	75	72	304	28	332	80	80	15.6
" 27	"	Good	"	76	86	284	52	336	100	88	16.3
July 5	Dark	Little	Little	81	90	252	20	272	50	48	16.3
" 9	Light, turbid	None	Fine	77	88	260	30	290	62	54	15.6
† " 18	"	Little	"	76	75	260	40	300	40	40	22.0
‡ " 24	Light	Good	"	77	78	246	26	272	22	22	15.6
Aug. 1	Yellow	"	"	80	95	234	22	256	40	34	17.8
" 9	"	Little	Little	82	88	244	4	248	40	38	14.2
§ " 17	Dark, turbid	Good	Granular	78	88	222	108	330	44	38	15.6
" 29	Yellow	"	Sandy	82	92	170	118	288	42	20	13.5
Sept. 5	Yellow, turbid	"	"	78	88	258	26	284	56	48	12.1
‖ " 12	Light yellow, turbid	"	"	75	86	224	48	272	48	48	14.9
	Averages					250	76	326	53	46	15.0

* June 13. Rain night before collection. Sample delayed.
† July 18. Rain during two days preceding collection.
‡ July 24. Heavy rain day previous to collection.
§ Aug. 17. Heavy rains during four days previous to collection.
‖ Sept. 12. Delayed.

TABLE LV—*Havana—*

1900.											
June 7	Light, turbid	Earthy	Dark, sandy	68°	78°	272	106	378	42	40	12.8
" 14	Light	Good	Little	68	66	256	96	352	52	52	12.8
" 19	"	Little	Sandy	68	65	270	88	358	72	70	11.4
" 26	"	Earthy	"	70	88	248	76	324	72	64	12.1
July 2	Light, turbid	"	"	78	90	288	42	330	78	76	11.4
" 10	Light	Little	Fine, dark	78	82	268	84	352	64	60	14.2
* " 17	Light, turbid	"	Very fine	76	78	252	86	338	72	56	14.9
" 24	Light yellow	None	Fine	76	80	264	46	310	54	40	22.7
" 31	Dark	Little	"	70	64	248	38	286	42	36	14.2
Aug. 7	Yellow	"	Dark	78	80	226	18	244	40	40	18.5
" 14	Yellow, very tur.	Not good	Clay	76	74	274	134	408	64	48	14.9
" 21	Light, turbid	Little	Fine	80	84	204	46	250	42	36	12.1
" 28	Yellow	Good	Sandy	78	80	228	48	276	48	34	16.3
†Sept. 4	Dark, turbid	Little	Fine	74	76	148	214	362	52	36	16.3
Oct. 10	Sandy	"	Sandy	60	52	240	20	260	36	32	21.3
	Averages					245	77	322	55	48	15.0

* July 17, rain at time of collection.
* September 4, heavy rain second day before collection.

TABLE LVI—*Havana—*

1900.											
July 31	Yellow	Good	Sandy	70°	64°	270	14	284	50	48	4.3
Aug. 7	"	"	Fine	78	60	254	6	260	40	40	5.7
" 14	Yellow, turbid	"	Sandy	76	74	240	90	330	58	46	4.3
" 21	Yellow	None	Heavy clay			134	306	440	64	28	3,5
	Averages					224	104	328	53	40	4.4

The Illinois River.

Oxygen Absorbed. Not filtered	Oxygen Absorbed. Filtered	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates	Nitrogen. In nitrites	Nitrogen by Kjeldahl process	Colonies—per cc	Fermentation. 1-10 cc. (Per cent)	Fermentation. 1 cc. (Per cent)	Coagulation of Milk.	Indol produced?
17.44	6.56	0.50	0.98	0.68	0.05	....	43,500	25	5	24 hours......	Yes..
6.72	6.32	0.77	0.49	0.56	0.12	....	6,500	30	15	15 hours......	No...
5.68	5.20	0.40	0.45	1.20	0.14	....	105,600	20	70	24 hours......	Yes..
6.48	5.34	0.45	0.54	0.68	0.14	....	88,800	30	None..	"	" ..
5.60	4.72	0.12	0.44	1.00	0.44	....	16,000	50	20	Rapid	No...
5.28	4.88	0.49	0.39	1.04	0.44	....	52,500	30	30	24 hours......	" ..
5.44	4.96	0.40	0.36	0.40	0.24	1.32	12,000	10	20	20 hours......	" ..
6.16	4.96	0.50	0.36	0.60	0.20	1.56	24,000	40	10	Rapid	Yes..
5.60	4.08	0.34	0.48	0.60	0.08	0.94	450,000	20	10	"	No...
5.60	4.80	0.41	0.36	0.80	0.04	....	136,000	20	30	"	" ..
7.60	6.00	0.32	0.38	0.40	0.12	1.33	240,000	50	55	"	Yes..
8.48	4.96	0.39	0.40	0.32	0.24	1.47	72,000	None	25	"	No...
4.96	4.56	0.18	0.46	0.40	0.12	1.30	70,400	5	10	Very rapid...	" ..
8.00	6.72	0.38	0.40	0.80	0.12	1.46	449,000	10	20	Rapid	" ..
6.08	5.76	0.28	0.38	1.72	0.08	....	....	......	....	....	......
7.01	5.31	0.39	0.46	0.74	0.17	1.34					

The Illinois River.

8.16	5.60	0.38	0.37	1.00	0.10	....	16,600	60	80	15 hours	Yes .
6.96	5.04	0.44	0.39	1.20	0.14	....	345,600	50	10	24 hours	"
6.32	5.68	0.65	0.52	0.92	0.18	....	108,000	None	40	"	No ..
6.72	5.20	0.52	0.48	1.40	0.12	....	Plates liquified	10	15	"	"
5.52	4.56	0.33	0.40	1.00	0.24	....	82,000	20	20	Rapid	"
5.92	4.48	0.12	0.40	0.48	0.40	....	2,500	50	50	"	"
6.72	5.04	0.44	0.38	0.12	0.14	....	8,500	20	60	24 hours	"
6.32	5.20	0.49	0.45	0.72	0.12	....	25,000	30	80	"	"
5.76	4.56	0.40	0.25	0.72	0.16	....	83,500	50	50	20 hours	"
6.72	6.24	0.23	0.54	0.80	0.24	....	292,500	25	25	Slow	"
8.56	5.92	0.60	0.59	None..	0.04	....	161,000	15	20	24 hours	"
5.84	4.88	0.15	0.26	0.48	0.24	....	55,500	40	40	"	"
5.60	4.72	0.13	0.48	0.60	0.24	....	32,000	50	20	20 hours	"
6.80	6.00	0.14	0.33	1.16	0.16	....	93,000	10	45	Rapid	"
5.04	3.92	1.18	0.31	0.92	0.12	....	....	......	....	....	......
6.46	5.14	0.41	0.41	0.77	0.18	....					

The Spoon River.

5.60	4.80	0.20	0.48	Trace .	0.04	1.15	14,800	30	30	Slow.........	No ..
6.96	6.16	0.33	0.41	" ..	0.08	1.27	Liquif'd	15	40	"	"
5.68	5.44	0.42	0.42	None..	0.12	1.66	193,000	50	30	24 hours	"
13.60	5.84	0.12	0.56	0.32	0.08	1.58	122,500	50	40	20 hours	Yes .
7.96	5.56	0.27	0.47	0,08	0.08	1.41					

TABLE LVII—*Pearl*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Loss on Ignition. Not filtered	Loss on Ignition. Filtered	Chlorine
1900												
June	7	Light, turbid....	None........	Clay........	80°	85°	288	194	482	44	40	8.5
"	14	Light............	Earthy......	Sandy.......	73	84	268	222	490	74	46	9.2
"	19	"	Good........	"	77	84	264	52	316	52	52	9.2
"	26	"	Earthy......	"	79	87	306	138	444	90	72	12.8
July	3	Light turbid....	Good........	"	82	95	260	122	382	42	36	11.4
"	10	" "	None........	Fine........	82	75	242	72	314	54	44	9.2
* "	17	" "	Not good....	"	80	76	236	82	318	38	26	10.6
"	24	" "	Good........	None........	83	80	254	52	306	50	34	16.3
Aug.	2	" "	Earthy......	Flocculent..	82	98	230	42	272	30	26	13.5
"	9	Light............	Good........	Sandy.......	88	102	260	44	304	48	28	14.2
† "	16	Yellow..........	Earthy......	Yellow......	88	98	240	1236	1476	88	40	13.5
‡ "	23	Dark yellow.....	Good........	Sandy.......	88	96	180	280	460	64	30	8.5
"	31	Yellow..........	Earthy......	"	90	102	230	150	380	48	40	13.5
§Oct.	2	"	Good........	"	76	94	266	94	360	52	40	12.8
		Averages......	....	....	....	....	252	198	450	55	39	11.6

* July 17. Rain night before collection
† Aug. 16. Heavy rains, river muddy.
‡ Aug. 23. Heavy rains, river muddy, bacterial sample warm.
§ Oct. 2. River high.

TABLE LVIII—*Grafton*—

Date.		Color.	Odor.	Sediment.	Temperature. Water	Temperature. Air	Solids. In solution	Solids. In suspension	Solids. Total	Oxygen Absorption. Not filtered	Oxygen Absorption. Filtered	Chlorine
1899												
*June	7	Light, turbid....	Good........	Sandy......	76°	74°	280	102	382	86	62	7.1
"	14	Yellow..........	None........	Clay........	78	89	280	254	534	46	44	9.2
"	19	Light............	Good........	Little.......	77	86	260	92	352	74	60	9.2
"	26	Light, turbid....	"	Sandy......	80	90	204	184	388	44	36	9.2
July	3	"	"	"	82	88	272	114	386	94	76	11.4
"	10	Yellow..........	None........	Fine........	87	78	222	74	296	52	50	9.2
"	17	Light, turbid....	Good........	Very fine...	81	75	260	42	302	68	64	11.4
"	24	Yellow, turbid..	None........	Fine........	83	90	208	72	280	46	44	9.9
† "	31	Very light.......	Good........	None........	83	96	244	20	264	40	36	14.9
Aug.	7	Light............	None........	Very little..	88	96	294	6	300	52	46	12.0
"	14	"	Good........	Little.......	87	90	272	36	308	48	42	14.9
"	21	Yellow..........	"	Sandy......	86	94	200	136	336	64	60	9.9
"	28	Light, turbid....	"	"	84	92	206	94	300	54	32	11.4
Sept.	4	Dark, turbid.....	"	"	82	86	214	70	284	54	42	10.6
"	10	Yellow, turbid..	"	"	83	88	226	86	312	48	32	9.2
"	17	Light, yellow....	"	"	73	70	264	68	332	72	48	11.4
"	24	Yellow..........	"	"	68	82	234	42	276	40	36	10.6
		Averages....	....	....	....	....	243	88	331	57	47	10.6

* Sample delayed.
† River rising and muddy.

The Illinois River.

Oxygen Absorbed. Not filtered..	Oxygen Absorbed. Filtered	Ammonia. Free.........	Ammonia. Albuminoid.	Nitrogen. In nitrates...	Nitrogen. In nitrites...	Colonies—per cc.......	Fermentation. 1-10 cc. (Per cent)......	Fermentation. 1 cc. (Per cent)......	Coagulation of Milk.	Indol produced?......
7.92	6.24	0.17	0.45	0.80	0.01	12,800	80	None..	24 hours............	No...
7.20	4.80	0·14	0.46	1.28	0.06	Liquefi'd	None..	" ..	Slow...............	" ..
6.24	4.56	0.10	0.43	1.00	0.08	1,100	" ..	" ..	"	" ..
7.20	4.96	0.08	0.56	1.40	0.32	3,200	" ..	10	Rapid..............	" ..
6.16	5.68	0.11	0.31	1.60	0.01	1,900	" 45	30	24 hours...........	" ..
5.44	4.56	0.08	0.33	0.40	0.16	500	None..	None..	Rapid..............	" ..
7.84	6.08	0.07	0.32	0.60	0.08	5,500	10	10	24 hours...........	" ..
4.64	4.24	0.08	0.41	0.88	0.06	21,500	10	None..	12 "	" ..
5.20	4.32	0.08	0.20	0.88	0.04	31,000	30	40	24 "	" ..
5.68	4.88	0.14	0.46	None....	0.01	142,000	90	15	20 "	" ..
13.44	4 80	0.30	0.98	0.40	0.01	330,000	10	15	24 "	" ..
6.16	4.56	0.12	0.48	0.32	Trace....	52,000	25	80	15 "	" ..
6.08	5.28	0.10	0.38	0.16	0.12	‖				
6.96	5.92	0.18	0.33	0.80	0.08	Liquefi'd	20	25	15 "	" ..
6.87	5.06	0.12	0.43	0.75	0.07					

‖ Delayed, bacterial sample warm.

The Illinois River.

Oxygen Absorbed. Not filtered	Oxygen Absorbed. Filtered ..	Ammonia. Free	Ammonia. Albuminoid	Nitrogen. In nitrates.	Nitrogen. In nitrites..	Nitrogen by Kjeldahl process.......	Colonies—per cc	Fermentation. 1-10cc. (Per cent).....	Fermentation. 1 cc. (Per cent).....	Coagulation of Milk.	Indol produced? ....
8.00	5.52	0.09	0.42	1.12	Trace..	1.14	148,800	80	80	Slow.........	No...
7.36	5.20	0.13	0.45	1.36	None..	1.18	2,100	None	None..	"	" ..
5.28	4.16	0.10	0.34	1.40	0.02	1.23	4,600	50	50	24 hours.....	" ..
7.28	5.44	0.18	0.56	1.08	0.10	1.30	6,000	10	10	Rapid	" ..
6.96	4.80	0.11	0.31	1.44	0.01	1.16	5,500	50	10	Slow.........	" ..
5.20	4.72	0.07	0.35	0.60	0.08	0.88	5,000	None	50	"	" ..
5.04	4.80	0.04	0.27	0.32	0.04	0.94	4,500	20	10	"	" ..
5.36	5.12	0.05	0.28	1.00	0.04	0.94	1,400	60	10	"	" ..
4.88	4.08	0.02	0.24	0.72	Trace..	0.84	1,200	None	30	30 hours.....	" ..
5.44	4.88	0.06	0.39	0.80	0.02	1.28	Pl's liq'd	10	10	18 "	" ..
5.52	4.96	0.09	0.44	0.28	0.02	1.14	4,500	35	60	20 "	" ..
6.56	5.36	0.05	0.36	0.28	0.02	1.19	13,000	15	10	Very rapid..	" ..
6.08	5.20	0.10	0.34	0.80	0.04	1.23	4,600	35	35	24 hours.....	" ..
5 60	4.80	0.03	0.28	1.00	0.08	1.17	95,000	35	50	Rapid	" ..
5.36	4.64	0.02	0.35	1.04	0.04	1.33	161,000	25	20	24 hours.....	" ..
5.52	4.64	0.03	0.34	1.20	0.02	....	1,400	10	20	20 "	" ..
4.16	3.68	......	......	0.40	0.02	....	Liquef'd	15	20	24 "	" ..
5.85	4.82	0.07	0.36	0.87	0.03	1.13					

Table LIX—*Grafton*—

Date.		Color.	Odor.	Sediment.	Temperature.		Solids.			Loss on Ignition.		Chlorine......
					Water....	Air......	In solution.	In suspension.....	Total......	Not filtered	Filtered....	
1900.												
July	31	Very dark.......	Little.......	Heavy clay.	82°	96°	144	474	618	66	32	2.8
Aug.	7	Yellow, turbid..	None.........	Yellow......	83	96	184	122	306	44	44	2.5
"	14	Yellow..........	Earthy......	Dark........	84	90	160	92	252	48	42	2.1
Sept.	10	Yellow, turbid..	Good........	Sandy.......	82	88	150	108	258	50	48	1.4
"	17	Dark yellow....	"	Clay........	71	70	142	138	280	56	44	2.1
"	24	Yellow..........	"	Sandy.......	70	82	130	236	366	54	32	1.4
		Averages....	....	....	....	....	152	195	347	53	40	2.0

Table LX—*Browning*—

1900.												
*Aug.	27	Light turbid....	Good........	Sandy......	83°	80°	424	42	466	86	72	5.0
"	30	Yellow..........	Earthy......	"	82	83	180	140	320	44	32	2.8
Sept.	5	Yellow turbid...	Good........	"	81	85	226	90	316	52	44	13.5
		Averages....	....	....	....	....	277	90	367	61	49	7.1

*Aug. 27, river very high.

T BLE LXI—*Wilmington*—

1900.												
†Aug.	22	Dark............	Good........	Brown......	78°	82°	180	76	256	42	42	2.1
Sept.	5	Yellow turbid...	"	Sandy......	78	88	250	58	308	56	46	2.1
"	11	Yellow..........	"	"	80	92	304	30	334	74	72	1.4
		Averages....	....	....	....	....	244	55	299	57	53	1.8

†Aug. 22, river very muddy.

The Mississippi River.

Oxygen Absorbed.		Ammonia.		Nitrogen.		Nitrogen by Kjeldahl process......	Colonies—per cc	Fermentation.		Coagulation of milk.	Indol produced?....
Not filtered	Filtered	Free........	Albuminoid	In nitrates.	In nitrites.			1-10 cc......	1 cc.........		
16.64	6.96	0.06	0.63	None..	Trace..	1.53	1,400	30	25	16 hours.....	No ..
15.84	10.08	0 14	0 53	" ..	None..	1.43	Liquefi'd	5	25	Very slow...	" ..
6 00	5.92	0.08	0.39	" ..	Trace..	1.30	2,500	50	60	24 hours.....	" ..
11.44	8.16	0.04	0.62	0.20	0.08	1.68	62,000	10	10	"	" ..
12.00	5.44	0.03	0.53	Trace..	Trace..	....	2,000	10	20	20 hours.....	" ..
8.48	5.92	......	......	None..	0.01	....	Liquefi'd	15	15	24 hours.....	" ..
11.73	7.08	0.07	0.54	0.03	0.02	1.49					

The Sangamon River.

6.16	5.44	0.09	0.28	0.24	0.08	1.31	13,000	30	30	24 hours	No...
7.04	6.40	0.06	0.32	None..	0.04	1.28	5,500	50	15	24 hours	" ..
5.76	4.88	0.04	0.44	0.80	0.48	1.10	2,500	50	25	24 hours	" ..
6.32	5.57	0.06	0.35	0.35	0.20	1.23					

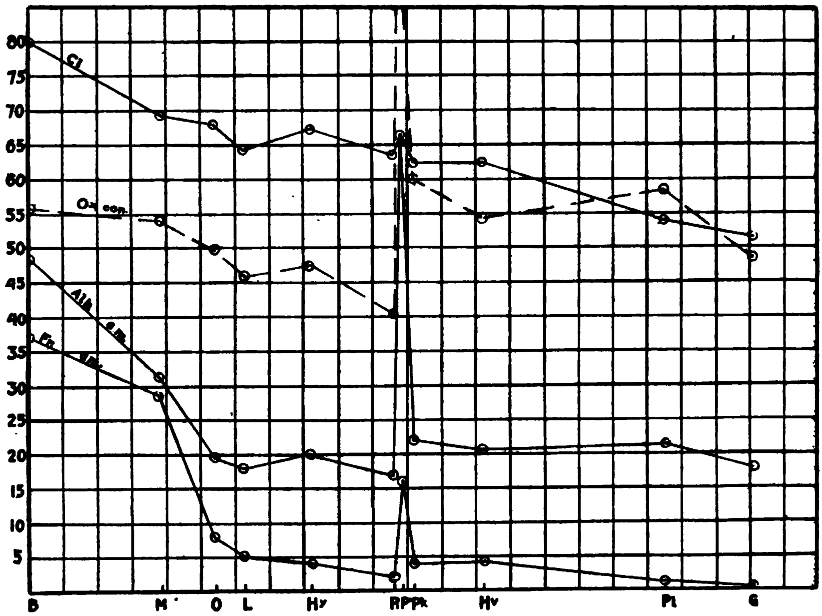
The Kankakee River.

7.44	6.88	0.13	0.39	0.60	0.06	1.26	45,500	20	40	15 hours	No...
10.08	7.68	0.10	0.50	0.80	0.08	1.40	3,300	70	20	20 hours	Yes..
10.08	8.48	0.08	0.48	0.92	0.04	1.55	1,200	20	40	Slow.........	No...
9.20	7.68	0.10	0.46	0.77	0.06	1.40					

TABLE LXII.—*Averages for Summer 1900.*

	Total solids	Loss on Ignition.		Oxygen Absorption.		Chlorine............	Free Ammonia......	Alb. Ammonia	Nitrogen in nitrates	Nitrogen in nitrites.	Organic nitrogen. (Kjeldahl)........
		Not filtered	Filtered ...	Not filtered	Filtered ...						
Chicago, lake..........	148	17	17	2.93	2.93	2.17	0.016	0.094	Tr...	0.00	......
Bridgeport, I. & M canal...	447	76	54	16.31	9.11	89.7	15.26	2.55	0.13	0.17	13.85
Western av. drainage canal	203	44	38	6.23	4.42	9.2	1.34	0.95	0.12	0.11	2.58
Lockport, basin	212	42	34	5.29	4.34	12.6	2.16	0.76	.00	0.06	......
Joliet, Desplaines river and canal.................	280	54	44	6.97	4.52	31.4	4.66	0.85	0.02	0.09	......
Wilmin'ton,Kankakee riv'r	299	57	53	9.20	7.68	1.8	0.10	0.46	0.77	0.06	1.40
Morris, Illinois river.......	251	44	39	6.40	4.66	17.8	2.84	0.63	0.17	0.27	......
Ottawa, Illinois river	266	50	44	5.94	5.03	17.2	0.81	0.39	0.92	0.37	......
Ottawa, Fox river	312	79	72	6.77	6.32	4.9	0.11	0.50	.00	0.02	1.25
LaSalle, Illinois river......	278	48	44	5.60	4.83	15.8	0.55	0.36	0.77	0.25	......
LaSalle, Vermilion river ..	283	63	48	5.89	5.23	9.5	0.12	0.32	0.43	0.10	1.30
Henry, Illinois river	283	51	44	5.86	4.86	16.9	0.41	0.40	1.06	0.22	......
Peoria, (narrows) Illinois..	265	49	43	5.05	4.53	15.5	0.21	0.34	0.95	0.12	......
Peoria, (Wesley) Illinois ..	333	65	52	9.91	6.59	16.6	1.62	1.34	0.72	0.11	......
Pekin, Illinois river........	326	53	46	7.01	5.31	15.0	0.39	0.46	0.74	0.17	1.34
Havana, Illinois river......	322	55	48	6.46	5.14	15.0	0.41	0.41	0.77	0.18	......
Havana, Spoon river.......	328	53	40	7.96	5.56	4.4	0.27	0.47	0.08	0.08	1.41
Browning, Sangamon......	367	61	49	6.32	5.57	7.1	0.06	0.35	0.35	0.20	1.23
Pearl, Illinois	450	55	39	6.87	5.06	11.6	0.12	0.43	0.75	0.07	......
Grafton, Illinois............	331	57	47	5.85	4.82	10.6	0.07	0.36	0.87	0.03	1.13
Grafton, Mississippi.......	347	53	40	11.73	7.08	2.0	0.07	0.54	0.03	0.02	1.49

GRAPHIC CHART DRAWN FROM THE TABLE OF AVERAGES (LXII) FOR THE SUMMER OBSERVATIONS 1900.



The letters on the abscissa line represent the points where water was collected, in the order: Bridgeport, Morris, Ottawa, LaSalle, Henry, Peoria (upper), Peoria (lower), Pekin, Havana, Pearl, Grafton. The values for Bridgeport are reduced from the observations for both canals on the assumption that the water left Chicago in one channel. Along the axis of ordinates the spaces have the following values: For chlorine (Cl) one space represents 2 parts per million, starting from 25 as base line. For free ammonia (Fr. am.) one space represents ½ part per million, starting from zero. For albuminoid ammonia (Alb. am.) one space represents 1-10 part per million with base at zero. For oxygen consumption one space represents ½ part per million with base at — 10.

Inasmuch as the flow in the old canal was irregular and variable throughout the summer of 1900 it was found necessary to make determinations here as well as in the new drainage canal. Through much of the time the larger part of the stock-yards sewage, which finally left the city, seemed to be carried by the way of the Bridgeport pumps; hence calculations based on the discharge become difficult on account of lack of specific information as to the amount of

flow through each channel from day to day. After the middle of July, 1900, when the Bridgeport pumps passed from the city into the control of the sanitary district more careful returns were kept and the figures furnished will be referred to below.

Our main interest in these tables lies in the relation of the quality and quantity of the dissolved and suspended substances at Bridgeport and the entrance of the drainage canal, as compared with the amounts of the same substances at Grafton, at the mouth of the river. A consideration of the nature of the Bridgeport water, as it was before the opening of the large canal, is first in order.

Practically this may be looked upon as made up from three sources:

1. House drainage and industrial sewage.
2. Diluting lake water.
3. Stock-yards sewage.

1. At the time this work was begun the Chicago river received the whole of the drainage from the West Side of Chicago, and from the North Side essentially all with the exception of that from the 25th ward. From the South Side most of the sewage of the 3d, 4th, 32d, 33d and 34th wards went then and still goes to the lake; from the other wards the drainage is mainly to the river. From data furnished me by the Chicago city sewer department and from figures of the last school census, I estimate that from a population a little short of 2,000,000, the waste of 1,600,000 went into the river. On its way to the river this waste was carried down and diluted by the water supplied to this same fraction of the population. During 1899 the amount of water pumped was 109,755,909,894 gallons, which amounts to almost exactly 150 gallons per day for each individual of the estimated population of 2,000,000. This is equivalent to nearly 28,000 cubic feet per minute. If four-fifths of the population drain into the river the proportional volume of water discharged here would be 22,400 cubic feet per minute. But it was unquestionably more, because of the greater consumption of water in the industrial operations. It may be safely estimated that 26,000 cubic feet per minute passed through the sewers carrying the house drainage and industrial waste of a population of 1,600,000.

According to the investigations of E. Heiden and others the organic solid waste from the urine and feces of such a population should amount to over 120,000 kilograms daily, about 265,000 pounds, or 132.5 tons. I have no means of estimating the household waste exclusive of excreta, but the part which can be carried down in the sewers is not as large as might be at first thought supposed. The fats and soaps are mostly retained by catch basins, and these are the important items in ordinary sink drainage. I believe nothing has been done toward determining the organic industrial waste entering the Chicago sewers from any district outside the stock-yards, but I am inclined to think that from this source the amount is not sufficient to bring the grand total to over 150 tons for the 24 hours for the city, exclusive of the stock-yards.

From the investigations of Heiden and Weigelt, quoted by Koenig in his well known work on the contaminations of waters, as well as from numerous experiments and calculations which I have made myself, I estimate that the total excreted nitrogen, considered in the form of ammonia, which reaches the sewers, can not be less than 27,400 kilograms, about 60,300 pounds, or a little more than 30 tons daily. The nitrogen from industrial waste, exclusive of the stock-yards, is not large and may be neglected. The greater part of this nitrogen is in very freely soluble condition. If all of it were immediately converted into ammonia we should expect to find the free ammonia content of the Bridgeport water as 19.2 parts per million from this source alone, counting 35,000 cubic feet per minute (1,428,000,000 kilograms per day), as the average discharge. Supposing the Bridgeport pumps to discharge with the 35,000 cubic feet per minute 150 tons of organic matter daily, this would give 95.5 parts per million as the organic content.

2. The portion of the Bridgeport water which did not pass through the sewers is not large. This conclusion is reached in two ways. From the practical absence of current in the river it follows that the pumps lifted approximately what the sewers, located at different points, discharged. The same result follows from the figures given above. The volume of water pumped which flowed into the sewers was estimated as 26,000 cubic feet per minute, while the Bridgeport flow was not over 35,000 cubic feet. The amount and character of the dissolved organic matters in this diluting water are not important for the purposes of this investigation.

3. An extremely important factor in determining the character of the Bridgeport discharge is the drainage from the stock-yards sewers, and in former years the output of these was much greater in amount of organic matter than at the present time. In 1886 I made some examinations of the flow of the main sewer, and found that the organic matter discharged by it, when calculated to the dry condition amounted to over 112 tons daily, which is about equivalent to the closet sewage of a population of 1,350·000. This large content was exceeded greatly in earlier years when the commercial value of the waste was not appreciated. Several years later, in 1890 and 1891, I had occasion to make extended investigations of the character of the sewage reaching Bridgeport from several quarters. Over twenty complete tests were made on the sewage discharged from the Brennock and Ashland sewers combined, the samples being collected in such a manner as to secure a very accurate and fair average for the flow of the 24 hours. With a mean discharge of 1,336,000 cubic feet per day, the organic matter present was 2,428 parts per million, corresponding to 91,850 kilograms or about 101 tons daily. At the same period the discharge of the Halsted and 39th street sewers was 9.3 tons daily of dry, organic matter. The total nitrogen from the Ashland and Brennock sewers, counted as ammonia, was 418.5 parts per million, amounting to 15,820 kilograms, or 17.4 tons daily. From the Halsted and 39th street sewers the amount was 37.2 parts per million, corresponding to 1,406 kilograms daily, or 1.25 tons. For the two sewer systems the ratio of ammonia to total organic solids is nearly the same, and high enough to indicate the essential proteid character of the waste.

I believe these results may be applied to present conditions with a fair degree of accuracy. While many improvements have been made in processes for utilizing stock-yards waste, the gain is practically compensated for by the increased slaughtering of cattle and hogs. Extensions in the Ashland avenue and Halsted street sewer systems bring also a greatly increased amount of sewage from points south of the stock-yards, so that the final discharge must now be above the figures given. Approximately, then, the flow at Bridgeport can be taken as made up of city sewage containing 150 tons daily of dry organic matter and the combined stock-yards and Ashland and Halsted sewers, containing about 110 tons daily, but from the latter must be deducted the fraction of house sewage it contains, which in dry organic matter must amount to about 20 tons, as the contributing district has a population of about 200,000. Supposing the above assumption as to the constant flow from the stock-yards correct, we must add 90 tons of dry organic matter to that from the city flowing toward the Bridgeport pumps.

What fraction of this 240 tons actually passed the pumps into the old canal? The question is difficult to answer, because of uncertainty as to the volume of the water pumped, but in the investigations referred to, made nine years ago, the ratio of the discharge from the main city and stock-yards sewers to that passing the pumps, in cold weather, was 31 to 24. A part of this loss was due to sedimentation; in the south fork of the south branch this may be considerable in

winter. In hot weather there is an enormous loss in this part of the stream from fermentation or putrefaction changes. It is but necessary to watch the rapid escape of gas bubbles in the southern portions of the river to realize the importance of this. From the examination of 76 samples of water collected mostly in the fall months of 1890, and considering the flow then as now, as approximately 35,000 cubic feet per minute, I found that about 150 tons daily of dry organic matter and ammoniacal salts was actually passing the pumps. For the cold months of 1899 the amount was probably in excess of this, because of increase in population. During the summer it was probably lower, because of rapid destructive changes in the river itself.

We have now some idea of the extent of the pollution of the canal at its source and are ready for the question as to how far it and the river receiving it became purified in their flow to the Mississippi. This is a very complicated problem, and it must be said at the outset that the apparent purification found varies largely with the time of the year at which the examinations are made. The extent of apparent purification depends also on our arbitrarily assumed standards, and must, therefore, present different values to different observers. It is also necessary to separate the effect of dilution from that of apparent purification, for much of what appears to be a diminution in the amount of organic matter is merely a percentage decrease through addition of less contaminated diluting water. What we call purification in a flowing stream is properly an actual destruction of its organic matter, or conversion into organic matter of a harmless type, not in any way offensive to the senses. It also includes, and this is very important for the purpose of this investigation, the destruction in some manner of certain of its living vegetable forms, which at the present time are commonly looked upon as causative of various diseases. The destruction or disappearance of these vegetable species or bacteria, is in a large measure dependent on the disappearance of certain kinds of organic matter, and this latter is altered or destroyed mainly through the activity of bacteria themselves, which suffer in the process.

As a measure of the disappearance or alteration of organic matter we can conveniently take the changes in the observed oxygen absorption and albuminoid ammonia content, as defined above, and this will be done in what follows, in which the conditions prior to the opening of the drainage canal will be considered first. But first we must settle the question of average dilution of the canal water on its way to the Mississippi. Between Bridgeport and Grafton numerous streams mingle their waters with the original pump discharge; the effect of these must be considered. It is a matter of common knowledge that the flow of most of these streams is extremely variable, and single measurements of flow as usually made may give very misleading results. A method of somewhat greater accuracy depends on the determination of the chlorine at various points in the main stream and the important tributaries. The decrease in the chlorine found becomes a measure of the amount of diluting water, if the

chlorine content of the latter is known. The table below gives the average amount of chlorine at points along the canal, the Illinois and the larger tributaries, expressed in parts per million:

Bridgeport, canal	95.47	Henry, Illinois	43.20
Lockport, canal	96.97	Peoria (Narrows), Illinois	33.04
Lockport, Des Plaines	5.98	Peoria (Wesley), Illinois	34.97
Joliet, canal and Des Plaines	85.49	Pekin, Illinois	34.76
Wilmington, Kankakee	2.79	Havana, Illinois	29.17
Morris, Illinois	61.80	Havana, Spoon	4.16
Ottawa, Illinois	57.40	Browning, Sangamon	4.49
Ottawa, Fox	3.78	Pearl, Illinois	18.73
LaSalle, Illinois	41.30	Grafton, Illinois	17.50
LaSalle, Big Vermilion	38.35		

It will be observed that we have a slightly greater amount of chlorine at Lockport than at Bridgeport, which may be due to a concentration by evaporation on the way. There is again an increase between LaSalle and Henry, which may in part be due to the sewage of LaSalle and Peoria and partly to the fact that the canal is discharged below the point where the LaSalle samples were taken. The Vermilion river enters at LaSalle, but through most of the season it was very low and in chlorine content was but little better than sewage itself. Peoria and Pekin add appreciably to the chlorine, as shown by the figures for the latter place and Wesley, as contrasted with those for Peoria, Narrows.

One hundred volumes of water below the junction of the main stream and a tributary may be looked upon as made up of x parts of main channel water and $(100-x)$ parts of tributary water. If we have—

a parts of chlorine per unit volume in the main channel,
b parts of chlorine per unit volume in the tributary,
c parts of chlorine per unit volume after the union,

then,

$$a\,x+b\,(100-x)=100\,c$$

from which:

$$x=100\,\frac{c-b}{a-b}$$

Applying this formula to the water at Joliet we find that it was made up of 87.4 parts of canal flow and 12.6 of DesPlaines river water. Above Morris the Illinois is formed by the union of the canal and DesPlaines water with that from the Kankakee and DuPage, a stream similar to the Kankakee in general character. Assuming that their chlorine content was the same, we obtain as the composition at Morris, for 1899, 62.3 per cent of canal water and 37.7 per cent of diluting water. This leaves out of consideration the effect of the chlorine added by the Joliet sewage. Relatively, however, this effect is small, as was found in the former investigations for the Board. At LaSalle we have 40.4 per cent of canal water and 59.6 per cent of

dilution. At Havana, above the Spoon, there is about 27 per cent of original canal water and 73 per cent of dilution. The flow from the Spoon is variable, and during the latter part of the season was small, but that from the Sangamon and smaller tributaries is considerable. These tributaries make up 42 per cent of the flow at Pearl. The original canal water is now reduced to about 15.6 per cent, while at Grafton it probably goes below 15 per cent.

These data are, of course, only approximations, but in corresponding seasons somewhat similar results have been found by actual surveys. The enormous dilution between Havana (above the mouth of the Spoon) and Pearl is remarkable and can not be accounted for by the main tributaries, the Spoon and the Sangamon. Smaller streams, such as Crooked Creek, also enter, but their flow does not appear to be large. The marked decrease in the chlorine indicates dilution, however, beyond question. Practically the same evidence was given by the work of 1888. It must be remembered, however, that this part of central Illinois is a region of springs and a very large amount of water must enter the river from them. The bluffs along the west bank have furnished water to Peoria for years and similar conditions prevail above and below this place. Several of the little lakes near the river are largely fed by springs and in turn drain into the main channel. While it is quite impossible to estimate the flow of these springs, their effect must be borne in mind in considering the great dilution in the lower river. It is likely that the dilution between Henry and Peoria, referred to below, may be explained in this way.

From the data obtained I have calculated the following table, for the 1899 results, which gives the dilutions at different points in the river. Between LaSalle and Peoria there is a marked decrease in chlorine corresponding to a considerable dilution which can not be accounted for by the size of any of the streams entering. The greater part of this dilution falls below Henry, and I have made an arbitrary assumption of a 5 per cent dilution between LaSalle and Henry. The Peoria dilution is calculated also from LaSalle. The increased chlorine at Henry can not be readily accounted for and complicates the problem. The flow from the Big Vermilion, which is here estimated as falling below LaSalle, is often very high in chlorine, and from the following considerations may account for part of the increase. The Big Vermilion water is collected by a dam above Streator and is pumped from a connected reservoir to supply the town. The summer flow in the river above this place is very small and much below the sewage flow. The river below Streator is practically sewage in which the chlorine persists, while the organic matters appear to be pretty well oxidized. Some mine drainage also reaches the river. The water is at times very high in sulphates.

	Canal water..	Des Plaines.	Kankakee, DuPage, etc.	Small streams....	Fox, etc.....	Big & Little Vermilion..	Unknown dilution....	Mackinaw, etc	Spoon, Sangamon, etc..	Small streams....
Joliet...........	87.4	12.6	....	....	....	....	....	....	....	....
Morris	62.3	9.0	28.7	....	....	....	....	....	....	....
Ottawa.........	57.7	8.3	26 5	7.5	....	....	....	....	....	....
LaSalle	40.4	5.8	18.5	5.3	30.0	....	....	....	....	....
Henry	38.4	5.5	17.6	5.0	28.5	5.0	....	....	....	....
Peoria..........	31.2	4 5	14.3	4.1	23.2	3.8	18.9	....	....	....
Havana	26.9	3.9	12.3	3.5	20.0	3.3	16.3	13.8	....	....
Pearl	15.6	2.3	7.1	2.0	11.6	1.9	9.5	8.0	42.0	....
Grafton	14.4	2.1	6.6	1.8	10.7	1.7	8.8	7.4	38.8	7.7

For some of the smaller tributaries a chlorine content of 4 parts per million has been assumed in making the calculations. This is near the truth, as shown by the averages of the examinations made on similar waters. It may be very naturally objected that in some of the above tables, based on chlorine diminution, I have neglected to consider the effect of the lower river towns as well as of Joliet. But, as explained for Joliet, the salt in this contamination is small when compared with that already present, and the omission from the calculation can occasion no serious error. On the other hand I have said nothing about the slight but constant loss of chlorine which follows through absorption by certain kinds of plant life in some parts of the river at times. Neither effect is great enough to interfere with the approximate estimations, however.

By the aid of the tables above we can calculate what the organic contamination of the river, as measured by the ammonia and oxygen consumption, should have been through 1899, supposing no purification to have taken place, or no great sewage addition, such as furnished by Peoria, made. This follows by adding together the contaminations due to the fractions of canal and tributary waters which combine to make the flow at any point. In several instances, for the smaller tributaries not analyzed, it is necessary to assume that the diluting water carries about the same kind and amount of organic matter contained in similar streams that have been analyzed. The following table gives the results reached:

	Free Ammonia.		Albuminoid Ammonia.		Oxygen Consumed.	
	Found.	Calc.	Found.	Calc.	Found.	Calc.
Bridgeport	19.88	....	3.22	....	26.65	....
Lockport	19.86	19.88	3.33	3.22	27.90	26.65
Joliet..................................	16.05	17.38	2.89	2.97	25.69	25.40
Morris..................................	10.10	12.41	1.20	2.21	9.16	19.73
Ottawa.................................	6.23	10.50	0.62	2.06	7.13	18.63
LaSalle	4.67	8.10	0.59	1.58	6.99	15.20
Henry..................................	3.27	7.66	0.55	1.42	7.00	14.16
Peoria (1).............................	0.90	6.26	0.57	1.31	6.86	12.49
Peoria (2), Wesley..................	4.36	6.26	3.20	1.31	17.44	12.49
Pekin	1.40	6.26	0.83	1.31	7.81	12.49
Havana................................	1.70	5.45	0.70	1.20	7 18	12.00
Pearl....................................	0.32	3.20	0.67	0.86	5.51	9.76
Grafton................................	0.25	3 12	0.46	0.84	5.61	9.36
Grafton, the Mississippi...........	0.08	....	0.47	....	8.52	....

The table shows that the amounts of organic matter actually indicated are much below these calculated on the assumption explained. The rate of oxidation will appear all the more marked if we consider the effect of the contamination added at Peoria and Pekin. At Peoria Narrows a very advanced condition of oxidation is indicated, but below the city the increase in contamination is enormous. This, of course, is not mainly due to the ordinary sewage thrown into the stream, but to the effects of cattle-feeding, and discharged distillery slops. From calculations based on the number of cattle fed and the amount of grain mashed, I am convinced that the waste nitrogen here is practically equal to that discharged at Bridgeport, due allowance being made for the slop now dried and sold. Considering the dilution, the very high ammonias and oxygen consumption at Wesley certainly indicate more than this. The great difference between the Wesley and Pekin results may appear surprising, but this difference can be easily explained. During the summer months the river between the two places may be compared to a large septic tank, such as is now employed in many places for the partial purification of sewage. The rate of decomposition here is very rapid, and in a flow of about ten miles far-reaching changes occur. Much of the filth which runs into the river from the sheds settles, to be decomposed later. We have a condition here resembling that in the stock-yards branch of the Chicago river. The evolution of the gases of decomposition attests the activity of the bacterial scavengers. If all this material could have floated down the river without oxidation the result would be greatly different from that actually found. As it is, it must still be recognized that the Peoria cattle shed filth, and not the Chicago sewage, is the main factor in the animal pollution of the lower river.

Considering the evidence of the above tables it must be admitted that in this part of the river the organic matter has become largely oxidized and destroyed. The amount of albuminoid ammonia in the Illinois at Grafton was less than in the Mississippi at the same place, and the oxygen consumption was markedly less. The Illinois, at its mouth, was in better organic condition than are most of its tributaries. A larger flow would doubtless have produced no very great change except in the oxidation of the free ammonia. The organic matter left here is probably mainly that derived from the soil, and much of this is of such a character as to undergo change but slowly. At Grafton little beyond the harmless salt remained to tell of the enormous pollution 320 miles above. The physical appearance of the lower river and the extent of the fishing industry, aside from any data of chemistry or bacteriology, point clearly to the changes accomplished, and the clear stream which entered the Mississippi through the season of 1899 was not one which an unbiased observer could call seriously polluted.

With the opening of the large canal in the early spring of 1900 it was feared by many that this favorable condition would be changed, and in many quarters dire consequences were predicted. While it was recognized that a much greater flow of pure water from the lake would be provided for it was also plain that with this more sewage

must be carried. With the completion of the intercepting sewer system of the city, the whole of the city filth, instead of a part, must enter the canal, and the importance of this fact should not be overlooked. I have called attention above to the fact that in the south fork of the river the enormous stock-yards pollution presents a somewhat difficult problem. Not all of this reached the Bridgeport pumps under the old relations, because in the nearly stagnant condition of this part of the stream reactions sometimes took place almost as complete as in the English septic tank system of sewage purification. Much of the organic filth produced in that section of the city in certain seasons never left Chicago, but was destroyed by bacterial fermentation. It is known to all those interested in such matters that the new sewage system of the city provides for the rapid flushing of this south fork by means of a great volume of water drawn from the lake through the 39th street conduit now under construction. This conduit or tunnel, with an internal diameter of twenty feet, runs under 39th street from the lake to a point just north of the stock-yards, where it joins the extreme south end of the Chicago river, the discharge to be by gravity, as the top of the conduit is at low lake level (city datum), or by the aid of lifting pumps, to secure a still larger flow. This great conduit will receive the discharge of much of the southern part of the intercepting sewer system; and the addition of the water from it to the south fork will give such a velocity to this sluggish part of the stream that little time will be allowed for the oxidation changes now taking place there. The effect of this will be to materially increase the gross amount of organic matter entering either the new or old canal, but not the percentage amount, as the dilution will be correspondingly great. Certain oxidation changes now well advanced before the canals are reached, will have to be begun in the latter stage of the flow, and a retardation in purification may be noticed in the canal and upper Illinois, but the final result will not be materially changed. It is to be regretted that at the time of writing this report the conduit is still far from completion, as we are now left without certain data desirable in the drawing of final conclusions, and we can only estimate the effect of them.

In discussing the conditions through 1899 it was comparatively easy to follow the water from the Bridgeport pumps to the Illinois and down, but for the work of 1900 the case is far more complicated. During much of the time water was sent through both canals toward Joliet, but with great irregularity. Sometimes the Bridgeport pumps were not in operation, and for a short time the gates at Lockport, the discharge point of the drainage canal, were closed so that practically no water passed for days through the main channel. This made the collection of fair average samples a matter of great difficulty and uncertainty, and may account for some of the irregularities apparent in the figures given above.

Another point may also be noted. With a high lake level and wind from the east the water of the south fork may be completely banked up south of the Bridgeport pumps, so that comparatively clear water passes here also. There have been times during the sea-

son of 1900 when an enormous amount of stagnant filth collected in this way in the south fork, and I have seen it with a thick scum on top of such density that birds could walk on it as on dry land. With falling level in the lake and river, this great mass of sludge is rushed out and down both canals, making a sudden and pronounced change in the character of the flow. A study of the chlorine content shows that as a rule, however, the larger part of the stock-yards sewage passed down the old canal, while the remainder and the city sewage went through the drainage canal. The mixed sewage appears in passing Joliet.

Another important fact may also be noted in this place, and that is that the average volume of water passing through the two canals is much below what the final flow is expected to be. During part of the period covered by these analyses the engineering works at Joliet were not in a condition to permit the passage of a larger volume.

In following the changes in the sewage through the season of 1900 we must begin our comparisons at Joliet, since it is here that the mixed sewage actually first appears. From a study of the chlorine contents for the two seasons it would seem that the dilution in the portion of the second season under consideration is about three times that in the first. Later, with the increased flow permitted, the dilution became actually greater. But the chlorine values for Joliet are not absolutely certain because of the irregularity in the character of the flow from Bridgeport. While the chlorine content of the water coming through the drainage canal is reasonably constant, that from the Bridgeport pumps is extremely variable, as an examination of table XLII will show. The average of 89.7 parts per million is certainly too low in representing the average for the season if we consider the flow as uniform in both canals. On the other hand, the chlorine values at Joliet are probably too high for a fair average. The result here is apparently modified because of high chlorine from Bridgebort at times not shown in the tables.

During the season of 1899 the flow from the Kankakee and DuPage rivers was quite small, but in 1900 it was often large. The flow from the Kankakee alone was about 85,000 cubic feet per minute through much of the summer, according to data furnished me by Mr. Harman. The effect of this is observed at Morris, where the chlorine content drops to 17.8 parts per million. Below Morris we have a regular and gradual fall in the chlorine, corresponding to the dilution with water from the tributaries until the mouth of the river is reached at Grafton. The fall in chlorine, oxygen consumption, free ammonia and albuminoid ammonia is shown in chart II.

To illustrate the progressive purification, calculations might be made as was done with the results of the work of 1899; but they will not be necessary as the direct figures, in comparison with the earlier ones, are suggestive enough. We have at Grafton in this latter season a result much more satisfactory, even, than was that of 1899. The chlorine content, 10.6 parts per million, taken in connection with the character of the tributary waters, becomes a measure again of the extent of dilution. From data collected by the engineers of the Sanitary District it appears that the mean flow past Joliet during June,

July, August and September, 1900, was about 221,000 cubic feet per minute. For the same period, according to observations made at Peoria and furnished to me by Mr. Harman, the flow at that point was 382,000 cubic feet per minute. Assuming now that the chlorine in the diluting water between Peoria and Grafton is 5 parts per million we find that 58.0 per cent of the water at the upper bridge, Peoria, flowed past Joliet, and that 53.4 per cent of the Grafton flow passed Peoria. It follows, therefore, that about 31 per cent of the Grafton water passed the dam at Joliet. This is about double the proportion calculated from the results of 1899, but notwithstanding this fact, inasmuch as the gross discharge of filth through the Chicago canal was not greater, we find the evidence of organic pollution less marked than in former years.

In view of all the data collected, including the bacterial results, it is evident that the Illinois at its mouth is today purer than are the waters of any of its tributaries. It will be recalled that in the 1899 results are given the analyses of the waters from near the sources of the more important tributaries. These show clearly the character of the natural streams as they flow from the soil all over the State, and it is interesting to note that their proportion of organic matter is above rather than below that in the lower Illinois. The determinations of organic nitrogen by the Kjeldahl process, averaged in Table LXII, show interesting variations in this connection. At the mouth of the Illinois we have 1.13 parts of organic nitrogen per million as against 1.41 parts in the Spoon river, 1.23 in the Sangamon, 1.30 parts in the Big Vermilion, 1.25 parts in the Fox, 1.40 parts in the Kankakee, and 1.49 parts in the Mississippi opposite Grafton. Because of necessary differences in the form of combination, owing to longer contact with the destructive bacterial ferments, this nitrogen at Grafton undoubtedly represents a smaller weight of organic matter than is the case with the nitrogen in the upper tributaries. The residual organic nitrogen at Grafton represents probably a combination little prone to oxidation or change of any kind, and therefore of little moment from a danger standpoint.

THE BACTERIAL RESULTS.

As elsewhere explained in this report, the chemical tests were not the only ones carried out in the progress of the investigation. Parallel with these certain experiments were made on samples of water collected in a special manner to determine as well as possible the number and character of the bacterial organisms present. Results obtained in this way are far less certain than those secured by chemical methods, because of the inherent difficulties in collecting average samples and in transporting them from the point of collection to the laboratory for observation. The number, and character also, of the bacteria in a water may undergo a very great change during the time intervening between collection from the river and experimentation in the laboratory. Usually an increase in the number of germs present takes place, but this may sometimes be followed by a marked decrease through diminution in the food supply. Notwithstanding all

precautions taken to keep the temperature of the collected samples low during shipment, failure often follows, and uncertain results are obtained. Sometimes sufficient ice is not used around the bottle with the bacterial sample; sometimes there is a delay in delivery on the part of the express company, or sometimes the package is left in an exposed warm place by the shipper before the arrival of the train, or later at its point of destination it may be similarly exposed before delivery to the chemist. In several ways, then, it is possible to account for alterations in the character of the water, and these changes are further not without effect on some of the chemical results, especially in the amount of nitrogen present in the form of nitrates and nitrites.

But in the study of a series of bacterial examinations we obtain very valuable general information in spite of all these difficulties, and points of general importance may be brought out which can be reached in no other way. Taking the results, pointed out above, as a whole then, we see a gradual decline in the bacterial pollution between Chicago and Peoria, with finally a condition between Henry and Peoria which may be compared with that of the small and unpolluted streams. An enormous increase in bacterial life follows below Peoria and Pekin, with again a decrease toward the mouth of the river. There is in general, also, a change in the character of the bacterial organisms as indicated by the rapidity of fermentation, the production of indol and the coagulation of milk. These results are practically the same whichever series of observation we consider; the increased flow from Chicago has not increased the pollution at Grafton.

As to the specific nature of the bacteria present nothing will be said here, as this part of the subject is covered in the report of Professors Fütterer and Zeit, to which attention is called.

GENERAL CONCLUSIONS.

The main results stated in my preliminary report are confirmed and strengthened by the work subsequently done. It has been shown that in the stretch of the canal and river between Chicago and Peoria a remarkable destruction of organic matter is constantly taking place, not by sedimentation, as former critics of the work of the Board were anxious to believe, but by organic oxidation. In recent years such a condition as I reported in 1887 has not been reached in the river at Peoria, when temperature and rainfall seemed properly adjusted to secure the highest degree of purification, but we have now something approaching the situation as then observed. The great mass of organic filth passing Lockport is practically destroyed, or rendered harmless by conversion into stable compounds, while the myriads of bacterial cells depending on it for their existence have likewise disappeared. Save for the presence of inorganic remains, the chlorides and the nitrates of oxidation, there is nothing here to distinguish the Illinois from its unpolluted tributaries, which hold dissolved, mainly, the organic products of decay of vegetable matter. The condition below Peoria is vastly different from what it is above,

and largely because of the pollution frcm the cattle sheds at the distilleries. But this, also, disappears in time, and at Pearl and Grafton the normal river situation is again reached. I believe it may be safely said that if the whole of the sewage of Chicago were to be excluded from the Illinois river the condition at Grafton would remain unchanged as far as organic content and bacterial organisms are concerned. With the flow from Chicago excluded, there would be a diminution in the harmless nitrates and chlorides only.

With the present conditions at Peoria, it would be useless to talk of purifying the Chicago sewage before turning it into the canal; its great dilution renders it there inoffensive to the senses, and bacterial oxidation does the rest before Peoria is reached. If anything more is attempted for the Illinois river it must be done below Peoria. I believe that such an improvement is within the limits of the possible, although with exactly what means I am not prepared to state. Nothing of value can be done with the knowledge now at our command, but with a closer insight into the nature of bacterial oxidation, as it takes place under different conditions of temperature, dilution and pollution, it is not too much to hope that a more rapid destruction of organic matter may be accomplished by artificial means, and broadly speaking, through the proper addition of fresh bacterial cultures at the right time and place. To determine the best conditions for this rational bacterial treatment of rivers is one of the interesting sanitary problems of the future. Meanwhile, much may be accomplished for the Illinois by comparatively simple means. We have seen that the chief source of pollution in the lower river today is the cattle shed and distillery refuse from Peoria and Pekin. It would not be a difficult matter to destroy most of this organic waste by a septic tank process before discharging the water containing it into the river, and for the sake of the rapidly developing fishing industries, if for no other reason, this should be insisted upon. The consideration of this problem I recommend to the careful consideration of the proper authorities.

Respectfully submitted,

J. H. Long.

Northwestern University, Chicago, April, 1901.

CHEMICAL AND BACTERIAL EXAMINATIONS

OF THE

WATERS OF THE ILLINOIS RIVER

AND ITS

PRINCIPAL TRIBUTARIES

BY

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IDENTIFICATION OF BACTERIA

FOUND IN THE WATERS OF

THE ILLINOIS RIVER

AND ITS

PRINCIPAL TRIBUTARIES

DR. JAS. A. EGAN, *Secretary of the Illinois State Board of Health.*

DEAR SIR:—In submitting this report of the result of our efforts to identify the different bacteria found in the samples of water of the Illinois river and its principal tributaries, which we received from Prof. John H. Long, we want to point out first of all some of the difficulties surrounding such investigations and the numerous factors which should be considered when basing an opinion upon the results obtained. Such investigations must necessarily always be influenced more or less by the following principal factors, mentioned in brief:

The number of bacteria in river waters is greatly increased by high water and decreased by low water.

The changes in rapidity of flow, increase or decrease of organic substances, the effects of sedimentation, dilution, the influence of light and the pollution resulting after heavy rainfalls all contribute to these variations.

It is evident that a bacteriological examination at times of very high or very low water level must give results which differ materially. Almost anything could be proven by examinations during such extremes of the normal water level. The bacteriological flora of a river must be determined under certain conditions which will establish what we might call the normal impurity of a river. There must be no rains to increase the normal pollution of the stream and the water level should be falling when the examination is made. We have, unfortunately, no data with regard to these factors, so that some of our findings may have been influenced at times by abnormal conditions. For this reason we shall give total findings for all examinations from each point rather than the individual results of

each sample of water, which should then give a fair average. Under such conditions the results of chemical and bacteriological examinations are fairly uniform.

A seriously polluted water becomes pure again after flowing a certain distance.

The Seine becomes, 70 kilometers below Paris, of the same purity as before it entered Paris.

The Oder shows the same degree of purity 32 kilometers below Breslau which it had before entering that city.

The Isar shows the same degree of purity 33 kilometers below Munich after receiving the sewage of the city, that it had before entering Munich.

The Limmat receives the sewage of Zurich and purification takes place after flowing 14 kilometers.

Our efforts to determine the area or zone of bacterial self-purification of the Illinois river by studying the bacteriological flora of the waters from the different points of collection established along the river by Prof. Long, must of necessity be subject to the criticism that they were not made in loco, but from 4 oz. samples of water received in ice packing. Prof. Long has already in his report described the different points of collection and the manner in which the specimens were collected and shipped to the laboratory, and the results of quantitative bacteriological examination.

It is a well-known fact that the usual water bacteria may multiply rapidly in such water, whereas most of the pathogenic bacteria die in a few days, in consequence of the increase of water bacteria, or because they find no organic substances necessary for their existence, and on account of the unfavorable temperature.

When pathogenic bacteria and saprophytes are both present in such water, the former die in a few days. If no saprophytes are present, pathogenic bacteria will live for weeks and months in water which does not lack the nutrient substances required for their existence and propagation. In distilled water pathogenic bacteria die rapidly because the nutrient substances are lacking.

It would seem, therefore, that for the purification of a river water from pathogenic bacteria the presence of great numbers of saprophytes is desirable and this may serve as one of the reasons why we do not consider the number of bacteria per c. c. as a fair indication of the purity or pollution of a river. We take, in our foods and beverages, millions of bacteria which are harmless and entirely nonpathogenic, but may become infected when only a few pathogenic bacteria are present in the same. The saprophytes play an important role in the household of nature and a water may be teeming with water bacteria without necessarily being polluted.

The quantitative bacteriological examination must give way to the qualitative one if the bacteriological examination is to have any value. Only a few colonies per c. c. of pathogenic bacteria make a water infectious, whereas several hundred thousand colonies per c. c.

of the usual water bacteria are harmless and do not make a water impure, but rather tend to purify the same from any pathogenic bacteria which may have polluted this water temporarily. It is a significant fact that in spite of a most diligent search for the bacillus typhosus in the highly polluted waters of Bridgeport, Lockport, etc., during the past year, we never have been able to find this microorganism.

A number of experiments with tap water which we inoculated with different quantities of fresh bouillon cultures for bacillus typhosus and vibrio choleræ Asiaticæ in four series—

First series, temperature 20 degrees, C., diffuse daylight;
Second series, temperature 37 degrees, C., diffuse daylight;
Third series, temperature 20 degrees, C., dark-room;
Fourth series, temperature 37 degrees, C., dark-room—

demonstrated that these organisms die in a few days in our lake water. Light, cold, and a decrease of organic matter accelerate their death. The water bacteria increase as the pathogenic bacteria decrease from day to day, most marked at 20 degrees. When organic matter is added to the water in small quantity we obtain colonies of typhoid bacilli up to the tenth day at 20 degrees and the eighteenth day at 37 degrees. Addition of saprophytes destroys the typhoid bacillus much earlier, no doubt from the exhaustion of food supply.

Numerous efforts have been made to establish the bacteriological flora of sewage and fecal matter and thus gain a qualitative test of drinking waters for sewage pollution by examining the suspected water for those bacteria. Jordan (State Board of Health, Mass., 1890—Purification of Sewage and Water, p. 821), and Mez (Mikrosk. Wasseranalyse, Berlin, Springer. 1898), have studied the bacteriological flora of sewage and thus added materially to our ability in diagnosing sewage pollution of drinking waters. After all, the qualitative bacteriological examination of suspected water must determine the question as to whether a water is polluted or infectious. Counting of colonies alone has only a very limited significance. We should know whether pathogenic micro-organisms are present and those saprophytes which are found in sewage, refuse waters, factory wastes, etc., which may not be directly pathogenic but may, by fermentation and putrefaction of dead organic substances, produce poisonous products.

In our case it would seem that the presence of pathogenic and sewage bacteria, and their gradual disappearance as the sewage-laden river passes on, should decide the question as to whether such purification is possible or not.

One might argue that sewage bacteria may occur generally in nature and if looked for would be found. This is certainly true, for instance, of the bacillus coli communis which can be found in many articles of our foods and probably quite generally in nature everywhere. The same can be said of some saprophytes always found in sewage.

Only recently Weissenfeld (Zeitsch, f. Hyg., Vol. 35, p. 78) studied this question with regard to the bac. coli communis and concluded that the so-called colon group of bacilli can be cultivated from all

waters, good and bad, if only sufficiently large quantities of water are used for cultivation, and that also the animal experiment can not decide the question as to whether the colon bacillus was cultivated from good or bad water, because virulent colon bacilli may be found in both. A water with 36,000 colonies to the c.c. did not kill a Guinea pig when 1 c. cm was given by intraperitoneal injection, whereas the same dose of a water containing only 22 colonies to the c.c. killed an animal in 18 hours.

After all, we know that the specific sewage bacteria are absent in non-polluted water and that no pathogenic bacteria should be present in a fairly pure river water, and we believe, therefore, we are able to judge a water by their presence or absence, their increase or decrease.

The specimens of water, as soon as received from Prof. Long, were plated out in two series on gelatin and agar, 3 to 16 dilutions of each, in Petri dishes. One glucose agar plate was always made by Koch-Fränkel's mica-plate method for growth of anaerobes.

The gelatin plates were kept at a temperature of 20-22 degrees in the dark, agar plates in the incubator at 37 degrees.

All the plates were examined daily and pure cultures obtained on agar from the varying discrete colonies between the second and eleventh day.

The pure cultures were then subjected to such further study as seemed necessary for identification, such as growth on different culture media, fermentation, gas production, temperature optimum, reduction of nitrates, production of indol and coagulation of milk. Some of the cultures were easily identified, others with great difficulty only and some could not be identified at all with any of the bacteria described in the literature.

Our examinations cover a period of about fifteen months. The identification of some of the bacteria with forms described in the literature has not been an easy or a satisfactory task under the conditions. We abstain from naming or describing any *new organisms* which varied slightly from types described in the literature. Those we identified agreed in all the characteristics given in the literature.

Intra-peritoneal injections of Guinea pigs were made in most cases where a pathogenic organism was diagnosed. Intra peritoneal injection of a series of Guinea pigs was done with 4 c. c. of the water of every station.

Another series of Guinea pigs were inoculated by intra-peritoneal injection with 1 c. c. of a bouillon culture made by taking 1 c. c. of the suspected water and 5 c. c. nutritive bouillon and keeping the mixture in the incubator at 37 degrees for 24 hours.

This enriching method for pathogenic bacteria (Anreicherungs methode) frequently proved virulent when the water itself did not produce death by intra-peritoneal injection and is certainly much preferable to the simple injection of the water itself. The temperature of 37 degrees favors rapid multiplication of pathogenic bacteria and hinders the growth of water bacteria.

IDENTIFICATION OF BACTERIA.

Lake Michigan Tap Water—Seven examinations were made and the following micro-organisms identified:

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. B. coli communis	3	1. Microc. aquatilis	2
2. B. lactis aerogenes	1	2. Microc. flavus liquefaciens	1
3. Mucor rhizopodiformis	1*	3. Bac. subtilis	4
		4. Bac. mycoides	1
		5. Bac. mesentericus	3
		6. Bac. reticularis	1
		7. Bac. liquidus	2
		8. Bac. aquatilis	2
		9. Bac. fluorescens liquefaciens	1
		10. Bac. flavescens, Pohl	1
		11 Vibrio aquatilis, Gunther	2
		12. Vibrio aureus	1
		13. Sarcina rosea	1

*Pathogenic to rabbits.

Guinea pigs infected with 4 c. c. of the different specimens of water, intraperitoneally, all recovered. Three of the specimens containing pathogenic bacteria were placed in the incubator (37 degrees) for 24 hours with nutrient bouillon, one part of the water to five parts of the bouillon. Three guinea pigs received an intraperitoneal injection of 1 c. c. of this 24 hour bouillon culture. Only one died of sepsis. The blood of the animal contained B. coli communis. Subcutaneous injections caused only a local abscess, the animal recovering.

Some of these specimens of water contained a moderate variety of bacteria commonly found in sewage but only one of the samples contained virulent coli bacilli.

Western Avenue—Thirteen specimens were examined and the following bacteria identified:

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	9	1. Microc. candicans	3
2. Bac. lactis aerogenes	4	2. Microc. agilis	1
3. Bac. enteritidis	3	3. Sarcina lutea	2
4. Proteus vulgaris	6	4. Bac. subtilis	3
		5. Bac. mycoides	2
		6. Bac. mesentericus	2
		7. Bac. aquatilis sulcatus I	3
		8. Bac. aquatilis	3
		9. Bac. acidi lactici	2
		10. Yellow water bacillus	1
		11. Bac. cloacae-Jordan	3
		12. Bac. reticularis-Jordan	1
		13. Bac. delicatulus-Jordan	1
		14. Bac. ubiguitus-Jordan	1
		15. Bac. albus putidus	1
		16. Vibrio aquatilis, Gunther	1

Western Avenue—Intraperitoneal injection of guinea pigs with 4 c. c. of the sample of water did not prove fatal.

24 hour mixtures grown at 37 degrees of one part of water and five parts of nutrient bouillon caused a fatal septicemia by intraperitoneal injection of 1 c. c.

Several of the pure cultures of the bac. coli communis obtained from these samples were non-virulent, whereas the above mixture invariably proved fatal.

Bridgeport—Seven samples of water were received. The organisms identified are:

Pathogenic.	Number of times found.	Non-pathogenic.	Number ot times found.
1. Bac. coli communis	6	1. Microc. candicans	2
2. Bac. lactis aerogenes	4	2. Microc. flavus desidens	2
3. Bac. enteritidis	2	3. Bac. subtilis	2
4. Proteus vulgaris	6	4. Bac. mycoides	1
5. Bac. pyocaneus	2	5. Bac. mesentericus	1
		6. Bac. superficialis	2
		7. Bac. aquatilis sulcatus I	1
		8. Bac. aquatilis	1
		9. Bac. liquidus	1
		10. Bac. fluorescens liquefaciens	2
		11. Bac. acidi lactici	2
		12. Bac. rubidus	1
		13. Bac. aerogenes	1
		14. Bac. plicatus	1
		15. Bac. cyanogenus	1

Besides the above we found an organism like oospora farcinica and a rather large spindle or club-shaped bacillus with polar granules which we failed to identify with any similar organisms found in the literature.

Intraperitoneal injection of 4 c. c. of several samples of water into a Guinea pig did not produce death.

1 c. c. of a mixture of one part of water to five of bouillon, kept in the incubator over night at 37 degrees proved invariably fatal to Guinea pigs in a short time. Even sub-cutaneous injection of one Guinea pig produced a fatal septicemia.

Lockport—We received seven samples for identification which contained:

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	4	1. M. candicans	2
2. Bac. lactis aerogenes	2	2. M. flavus liquefaciens	1
3. Bac. enteritidis	1	3. M. luteus	1
4. Proteus vulgaris	2	4. Sarc. lutea	2
5. Bac. mirabilis	1	5. Sarc. aurantiaca	1
		6. Bac. subtilis	1
		7. Bac. mycoides	1
		8. Bac. aquatilis sulcatus I	1
		9. Bac. aquatilis	1
		10. Bac. acidi lactici	2
		11. Orange red water bac	1
		12. Bac. cloacae	1
		13. Bac. ubiquitus	2
		14. Bac. rubidus	1
		15. Bac. plicatus	1
		16. Oidium lactis	1
		17. Mucor mucedo	1

Intraperitoneal injection of 4 c. c. into Guinea pigs produced no effect.

24 hour mixture grown at 37 degrees of one part of water and five parts of bouillon was uncertain in its effects; some animals recovering after 2 c. c. by intraperitoneal injection. One promptly died of sepsis. All those recovering had an elevated temperature and lost rapidly in weight for several days. One died two weeks later after having apparently recovered. No cause for death could be made out post mortem and no bacteria were found in the blood or organs nor in the abdominal cavity.

In the animal which died promptly, the proteus forms were most prominent. Pure cultures of the Proteus mirabilis by subcutaneous injection killed an animal which had apparently recovered from an intraperitoneal inoculation of the 1:5 culture.

Joliet—Six samples of this water were examined and the following germs identified:

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	3	1. Microc. aquatilis	2
2. Bac. enteritidis	2	2. Microc aerogenes	2
3. Proteus vulgaris	3	3. Microc. luteus	1
		4. Sarcina lutea	3
		5. Bac. subtilis	1
		6. Bac. mycoides	3
		7. Bac. mesentericus	1
		8. Bac. aquatilis sulcatus I	1
		9. Bac. fluorescens liquefaciens	1
		10. Bac. cloacae	2
		11. Bac. superficialis	2
		12. Bac. fulvus	1
		13. Bac. plicatus	2
		14. Bac. rubidus	1
		15. Bac. mucor mucedo	1
		16. Saccharomyces cerevisiae	1
		17. Bac. cyanogenus	1

Intraperitoneal injection of 4 c. c. into Guinea pigs produced no effect. Of four Guinea pigs inoculated with 1 c .c. of a 24-hour culture at 37 degrees of one part of the different waters and five parts of bouillon by intraperitoneal injection, one died of sepsis, the others recovered.

Wilmington—Two specimens of the Kankakee river water received for indentification contained:

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
None found	....	1. Bac. subtilis	....
		2. Bac. mycoides	....
		3. Bac. mesentericus	....
		4. Bac. aquatilis	....
		5. Bac. plicatus	....

Intra-peritoneal injection of Guinea pigs with 4 c. c. of the water and a 24-hour bouillon culture (1:5 at 37 degrees) did not cause death of the animals.

Morris—Ten specimens of water from this locality received for diagnosis, contained:

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	6	1. Microc. candicans	2
2. Proteus vulgaris	4	2. Sarcina lutea	1
3. Proteus mirabilis	1	3. Sarcina rosea	1
4. Bac. tetani	1	4. Bac. subtilis	3
		5. Bac. mycoides	4
		6. Bac. aquatilis	3
		7. Bac. cloacae	1
		8. Bac. megaterium	2
		9. Bac. plicatus	2

Direct intra-peritoneal injection of one specimen of this water caused death of a Guinea pig in 11 days. No post-mortem findings or bacteria in blood or organs. Other samples of water from same place did not cause death by direct injection. Experiments with mixed cultures gave uncertain results.

Ottawa—Illinois river. Five samples of water were examined and contained:

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	2	1. Microc aerogenes	1
2. Proteus vulgaris	1	2. Microc. candicans	1
		3. Diploc. roseus	1
		4. Bac. subtilis	1
		5. Bac. mesentericus	1
		6. Bac. cloacae	1
		7. Bac. liquefaciens	1
		8. Bac. fulvus	1
		9. Vibrio flavus	1
		10. Pink yeast	1

Both the water and mixed cultures proved non-virulent after intra-peritoneal injection into Guinea pigs in the same manner.

Ottawa—Fox river. Four samples of water were received for identification of bacteria.

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	1	1. Diploc. citreus	1
		2. Diploc. roseus	1
		3. Sarcina lutea	1
		4. Bac. mycoides	1
		5. Bac. aquatilis sulcatus I	1
		6. Bac. liquidus	3
		7. Bac. aquatilis	3
		8. Bac. flavocoriaceus	1
		9. Bac. plicatus	1
		10. Orange red water bac.	1

Neither water nor mixed cultures proved pathogenic.

LaSalle—Six samples of water were examined.

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	2	1. Microc. albicans	1
2. Bac. enteritidis	2	2. Sarcina lutea	2
3. Proteus vulgaris	3	3. Bac. mycoides	3
		4. Bac. aquatilis sulcatus I	3
		5. Bac. aquatilis	2
		6. Bac. megaterium	2
		7. Bac. fulvus	1
		8. Bac. ochraceus	1
		9. Bac. plicatus	4
		10. Bac. subflavus	1
		11. Bac. rubidus	1
		12. Bac. cloacae	1
		13. Bac. oidium lactis	1
		14. Bac. pink yeast	1
		15. Vibrio aquatilis	1

One Guinea pig which received an intraperitoneal injection of 4 c. c. of the water samples died of sepsis, the others recovered, but the 1:5 bouillon mixture grown in the incubator for 24 hours proved very virulent.

Henry—Five samples of water were examined.

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	2	1. Sarc. rosea	1
2. Proteus vulgaris	1	2. Bac. subtilis	1
3. Bac. tetani	1	3. Bac. mesentericus	4
4. Staphylococcus pyogenes aureus	1	4. Bac. cloacae	1
		5. Bac. megaterium	1
		6. Bac. aquatilis sulcatus I	1
		7. Bac. aquatilis	2
		8. Bac. subflavus	2
		9. Bac. rubefaciens	1
		10. Bac. striatus flavus	1

Besides the above an organism like oospora farcinica was obtained again, but not positively identified.

Direct injection of the water did not cause death. Mixed bouillon cultures of 24 hours growth at 37 degrees were virulent.

Upper Peoria—Five samples of this water were examined.

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	....	1. Microc. citreus	....
		2. Sarcina aurantiaca	....
		3. Sarcina rosea	....
		4. Saccharomyces cerevisiae	....
		5. Pink yeast	....
		6. Bac. mesentericus	....
		7. Yellow water baccillus (Lustig)	....
		8. Bac. liquidus	....

Direct intraperitoneal injection of water as well as a mixed 24-hour bouillon culture proved entirely non-virulent. Even large doses of a

24-hour culture at 37 degrees of one part of water and five parts bouillon could be given to Guinea pigs by intraperitoneal injection without causing death.

Bacterial self-purification is practically complete here and the Illinois river at this location contains less evidence of sewage pollution from the standpoint of qualitative bacteriological examination, that is, less pathogenic and sewage pollution, than at any other point between Lake Michigan and Grafton.

Lower Peoria—Eleven samples of water were examined and the following identified:

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	8	1. Microc. aquatilis	4
2. Bac. lactis aerogenes	2	2. Microc. luteus	1
3. Proteus vulgaris	5	3. Bac. subtilis	5
		4. Bac. Mycoides	2
		5. Bac. mesentericus	2
		6. Bac. cloacae	2
		7. Bac. ubiquitus	2
		8. Bac. reticularis	2
		9. Bac. circulans	1
		10. Bac. fluorescens liquefaciens	2
		11. Bac. plicatus	2
		12. Bac. aquatilis	2
		13. Bac. acidi lactici	3

Direct intraperitoneal injection of 4 c. c. of one of the water samples (Oct. 11, 1900) caused death of Guinea pig in 11 days. Another animal died of sepsis within 24 hours after inoculation with 1 c. c. of a 24-hour mixture, grown at 37 degrees, of one part water and five parts bouillon.

Here again a perceptible increase of pathogenic and sewage bacteria has taken place. The bacteriological flora here becomes similar to that of Joliet.

Havana, Illinois River—Twelve samples of this water were examined.

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	3	1. Bac. subtilis	5
2. Bac. lactis aerogenes	1	2. Bac. mycoides	3
3. Proteus vulgaris	4	3. Bac. mesentericus	2
4. Proteus mirabilis	1	4. Bac. megaterium	3
5. Bac. anthracis	2	5. Bac. aquatilis sulcatus I	2
6. Staphylococcus pyogenes aureus	1	6. Bac. aquatilis	1
		7. Bac. cloacae	3
		8. Bac. acidi lactici	1
		9. Bac. fluorescens liquefaciens	1
		10. Bac. plicatus	2
		11. Bac. rubefaciens	1

Several of the specimens of this water proved highly pathogenic to Guinea pigs and white mice when intraperitoneal injections were given and numerous animal experiments were necessary to prove beyond any doubt that anthrax spores must have been in two samples of this water. At first considerable confusion arose from the great

number of pathogenic bacteria found and the similarity of bac. subtillis and bac. mycoides found in these waters in great number, with the anthrax bacillus.

The differentiation became simple enough after we injected pure cultures of the anthrax-like micro-organism, the animals inoculated with the anthrax like organisms recovering, whereas the others promptly died in 40-48 hours of anthrax bacteremia, the blood of all organs containing enormous numbers of anthrax bacilli.

The bac. coli communis and staphylococcus pyogenes aureus found a few times in these samples proved non-pathogenic when pure cultures were injected, whereas the proteus forms were pathogenic.

Havana, Spoon River—Eight samples of this water were examined.

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	1	1. Microc. luteus	2
2. Proteus vulgaris	2	2. Microc aquatilis	1
3. Bac. tetani	1	3. Bac. subtilis	4
		4. Bac. mycoides	1
		5. Bac. mesentericus	3
		6. Bac. megaterium	3
		7. Bac. aquatilis	3
		8. Bac. rubidus	1

Intraperitoneal injection of 4 c. c. into Guinea pigs in two cases did not prove fatal. One sample containing the bac, tetani was not injected because the water was not available when the diagnosis was made.

Culture of the water, one part, bouillon, 5 parts, kept at 37 degrees were non-pathogenic in doses of 1 c. c. by intraperitoneal injection.

Pearl—Ten samples were examined.

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	1	1. Microc. candicans	1
2. Proteus vulgaris	1	2. Aquatilis	1
		3. Sarc. rosea	1
		4. Sarc. lutea	1
		5. Bac. subtilis	3
		6. Bac. mycoides	5
		7. Bac. mesentericus	1
		8. Bac. megaterium	2
		9. Bac. aquatilis sulcatus	2
		10. Bac. aquatilis	4
		11. Bac. aurantiacus	1
		12. Bac. rubidus	1
		13. Bac. acidi lactici	1
		14. Bac. flavocoriaceus	1

Neither water nor 1:5 culture was pathogenic by intraperitoneal injection.

Grafton—Ten specimens of water were examined.

Pathogenic.	Number of times found.	Non-pathogenic.	Number of times found.
1. Bac. coli communis	2	1. Microc. luteus	1
2. Proteus vulgaris	2	2. Microc. aquatilis	1
3. Staphylococcus pyogenes aureus	1	3. Sarcina lutea	2
		4. Diploc. roseus	1
		5. Bac. subtilis	5
		6. Bac. mycoides	2
		7. Bac. megaterium	3
		8. Bac. aquatilis	2
		9. Bac. liquidus	3
		10. Bac. acidi lactici	2
		11. Bac. aurantiacus	1
		12. Bac. fluorescens liquefaciens	2
		13. Bac. subflavus	1

Intraperitoneal injection of 4 c. c. of the water into Guinea pigs did not cause death. Mixed cultures 1:5 also were non-pathogenic.

CONCLUSIONS.

1. Number of bacteria increase with high water and decrease with low water. To establish the *normal impurity of a river*, the water level should be falling and no rains to increase the normal pollution. Examinations should be made *in loco*.

2. A seriously polluted water becomes pure again after flowing a certain distance. Pathogenic bacteria and sewage bacteria decrease as organic matter decreases. At the same time water bacteria increase. The presence of saprophytes hastens the removal of organic matter and the death of pathogenic bacteria.

3. The quantitative bacteriological examination must give way to the qualitative, because a few infectious bacteria per c. c. constitute a more severe water pollution than a very great number of water bacteria.

4. No typhoid bacilli have been found in any of the samples. Experiments show that they die in a few days in Lake Michigan tap water. Addition of nutritive bouillon keeps them alive a longer time. If saprophytes are added at the same time, exhaustion of food supply again causes early death.

5. The bacteriological examination of a river water should be qualitative for pathogenic and sewage bacteria. The first are infectious, the second may cause poisonous products by fermentation or putrefaction.

6. Bacterial purification of a river can be judged by the gradual disappearance of pathogenic and sewage bacteria with falling water level.

7. The bac. coli communis may be found in water without sewage pollution, and if found may or may not be virulent.

8. A 24-hour culture of one part of the suspected water with five parts of nutritive bouillon, grown at 37 degrees, of which 1 c. c. is to be used for intraperitoneal injection into Guinea pigs, constitutes a better test for pathogenic effects than a similar injection of a larger quantity of the suspected water.

9. Intraperitoneal injection of 4 c. c. of the different water samples proved non-pathogenic in all cases except Morris, LaSalle, Lower Peoria and Havana.

10. Bouillon cultures, 1:5, as per No, 8 above, caused *death promptly* in water samples from Western avenue, Bridgeport, La-Salle, Henry, Lower Peoria, Havana—Illinois river.

Uncertain effect—Lake Michigan, Lockport, Joliet, Morris.

No effect—Wilmington, Ottawa, Illinois and Fox rivers, Havana, Spoon river, Pearl, Grafton.

11. Bacterial purification begins at Joliet. Sewage bacteria decrease markedly at Morris and still more at Ottawa, where the bacteriological flora of the Illinois river and Fox river do not reveal great differences.

12. Pathogenic and sewage bacteria increase again at La Salle and Henry.

13. The most marked bacterial purification occurs between Henry and Upper Peoria, where pathogenic and sewage bacteria are almost absent. Upper Peoria probably shows the least sewage pollution of any point between Chicago and Grafton.

14. At Lower Peoria we found a marked increase of pathogenic and sewage bacteria, similar to that of Joliet.

15. At Havana the conditions are worse and even anthrax, probably spores, were found here on two occasions.

16. At Pearl and Grafton much purification has again taken place but some pathogenic and sewage bacteria are still present.

17. An organism which resembles somewhat Oöspora farcinica (Noccard) was found and cultivated in pure cultures at Bridgeport, La Salle, Henry, Spoon River at Havana and Grafton.

18. Tetanus bacilli were found at Morris, Henry, and Spoon River, Havana. Anthrax bacilli were found twice at Havana, Illinois River. Of the pathogenic bacteria the bac. coli communis was found 55 times, bac. lactis aerogenes 16 times, bac, enteritidis 10 times proteus vulgaris 40 times, proteus mirabilis 3 times, bac. pyocyaneus 2 times, bac. tetani 3 times, staphylococcus pyogenes aureus 3 times, bac. anthracis 2 times.

Respectfully submitted,

F. Robert Zeit,

Gustav Fütterer.

REPORT

OF A

PRELIMINARY SANITARY SURVEY

OF THE

ILLINOIS RIVER DRAINAGE BASIN

MARCH, 1901.

BY

JACOB A. HARMAN, C. E.

SUBJECTS

Introductory.
The Illinois River, the ancient outlet of Lake Michigan.
Drainage basins of the Illinois.
Chicago water supply, sewerage and main drainage.
Population.
Stream gaugings and velocity.
Rain-fall tables.
Stages of Illinois River.
Discharge tables and data with discussion of rain-fall and run-off and comparative tables.
Water supply and sewerage.
Closure and and bibliography.

REPORT

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ILLINOIS RIVER DRAINAGE BASIN

BY

JACOB A. HARMAN, C. E.

Dr. James A. Egan, Secretary Illinois State Board of Health.

SIR:—The following report embraces the results of a sanitary survey of the Illinois river and its tributaries, begun in 1899. In June and July of that year Dr. John H. Long, chemist of the Board, and the writer, made an inspection of the Illinois for the purpose of locating stations for the collection of samples of water for analysis. Following is a brief description of the inspection as given in the advance notes of this report published in 1900.

Beginning at the mouth of the Chicago river—Lake Michigan—there was a slight appearance of sewage, which increased rapidly as the river was ascended, until the north branch was reached, from which point up the south branch to the Bridgeport pumping station the river was a seething, festering mass of decomposing sewage from house and factory, giving up great quantities of noisome gases; the surface of the river in many places having the appearance of a boiling caldron. From Bridgeport down the canal to Joliet it was as a stream of ink with a steady current and musty sewage odor. At Joliet the canal water so much exceeded the low water flow of the Des Plaines river that the dilution was inappreciable.

The next point of inspection was Morris, ten miles below the juncture of the Des Plaines and Kankakee rivers. At this point, in consequence of the dilution by the DuPage and Kankakee rivers and smaller streams, the river was much clearer but still showed some of the inky coloring from the canal. Inquiry developed the fact that years ago, prior to turning the Chicago sewage into the Illinois and Michigan canal, the river had teemed with fish, which generally are found in clear streams in this latitude, but of recent years no fish live in the river here.

Proceeding down the Illinois, the next inspection was made at Ottawa, where there was some clearing of the water, but no fishing. At LaSalle, however, the river was much better looking, having a yellow tinge, but only slightly turbid, and fish were occasionally caught.

At Henry is located the first dam on the lower Illinois river. The water was apparently good here, and from this point to Peoria fishing is quite an important industry. Dr. Forest, mayor of Henry, stated that the condition of the river was acceptable in the summer but in the winter the stench at openings in the ice was very suggestive of the Chicago river and that fish taken in the winter were unfit for food on account of the gases of putrefaction in the river water which seemed to permeate the flesh of the fish.

At Peoria a very noticeable change occurred in the river. Above the city the water had a slight yellow tinge and a fishy odor, below the city the stream is dark, almost as the Chicago river, due to the washings of the cattle barns, and the banks were strewn with dead fish. This condition was a little improved at Pekin, where another installment of stable washings was received. However, about ten miles below Pekin the water was very much cleared and fish were apparently abundant. At Copperas creek dam, about twenty miles below Pekin, the river had cleared to about the appearance above Peoria and fish were reported very plentiful.

From this point to the mouth the waters of the Illinois seemed to become clearer, except where affected by tributaries made turbid by recent rains. This inspection was made during the last days of June and first days of July, 1899, and covered the route of the sewage of Chicago from that city to the Mississippi river.

The work so far undertaken and carried out, consists of discharge observations at low water of the various streams tributary to the Illinois river, and a number of discharge observations of the Illinois river at Peoria, so that a curve and table of discharges for all stages of the river at that point is presented herewith.

The rainfall data from stations located on each water shed is tabulated and averaged for 10 years, 1890 to 1899 inclusive, and run-off from the territory above Peoria is shown in other tables, for the same period of time as well as for 1900. The latter year, however, is not included in the averages, as it was not made up until the last pages of the report were being prepared for the press.

The table of discharges shows the maximum, minimum and mean discharge in cubic feet per second, also the depth in inches over the entire area and the cubic feet per second flowing from each square mile of territory above Peoria for each month of the 10 years covered by the tables.

By comparing the tables of rainfall and run-off, the amount of water not flowing away in the streams, but evaporated from water and land surfaces and vegetation, in short the amount used in the processes of nature, is clearly set out.

In addition to the tables of rainfall and run-off, special tables of excessive rainfall at St. Louis, Mo., Milwaukee, Wis., Indianapolis, Ind., and rainfall in excess of 4 inches in 24 hours upon territory contiguous to the Illinois river basin; also table of heavy downpours with date, duration and amount of rainfall, if any, on preceding and succeeding days, have been collected and prepared for this report.

Circulars have been sent to mayors of all cities requesting detailed information regarding water supply and sewage systems and the data tabulated as hereinafter appears.

Population tables for 1890 and 1900 have been compiled from the United States Census and reports, and show the urban and rural population on each of the principal river basins tributary to the Illinois, thus showing where the greatest commercial activity and municipal growth have occurred and indicating where improvements in sanitary conditions will soonest demand attention.

All these data are pertinent to a general sanitary survey of the State of Illinois. The territory is so large that it has not been considered practicable with the limited means available to undertake a study of more than the Illinois River Drainage basin, but the other drainage systems of the State are deserving of careful consideration. Especially is this true throughout the southern portion of the State where it is very much more difficult to procure a water supply for municipal purposes, or even private wells for family use, than throughout the central and northern portions where water abounds and can generally be had for digging a few feet into the earth.

In connection with the statistical data given herein I wish to call particular attention to the preliminary report of this Board relating to water supplies of Illinois which was issued in 1889 and contains considerable data which has been made use of in this report and much more which is pertinent to a thorough comprehension of the drainage of the city of Chicago and protection of the Illinois river from sewage pollution.

When there is an abundant supply of rain distributed throughout the seasons, so as to meet the needs of vegetation, it is also generally true that the wastes of animal life and human industry are cleared from the atmosphere and gathered into the earth, streams and seas, there to be seized upon by the ever present and ready agents, which reduce these waste organic substances to harmless inorganic elements, to be again used in the world's economy.

The whole plan of terrestrial life is dependent for its very existence upon never failing recurrence of rain, distributed throughout the seasons. Fire and water are the great cleansing and purifying agencies, provided to maintain the earth in a healthful condition for man. Of these two agents, we rely more upon water, and any discussion or even conception of sanitary requirements must ultimately inquire minutely into the sources of water supply—primarily rainfall, —and the resources of the region for supplying man with what water he needs from day to day. Further than supplying him with water, there is equal need of means for removing and destroying that which is cast off by him as waste and injurious matter. This leads to a consideration of the drainage, which, together with the storage facilities of any region, is dependent upon its geological formation and topography. The rainfall, geology, topography and drainage of any region, therefore, determine for or against its desirability as a place of habitation for man, in that its capacity for supplying his needs and removing or converting his wastes are dependent upon these conditions.

The rapid development of manufacturing industries throughout the entire upper portion of the Illinois river valley and the resulting increase of urban population there, as well as the wonderful growth of Chicago, leads to the necessity of a very thorough study of the water resources of that entire territory, as well as of the opportunities for and the means to be employed in the disposal of sewage and garbage.

The method now in vogue in nearly all cases where any attempt at sewerage has been made is, in common with Chicago, to discharge the crude sewage into the nearest stream and depend upon dilution and oxidation to render the sewage harmless before it reaches the nearest community having an interest in the purity of the stream.

When the settlements are new and far apart the resources of nature, unaided, are usually equal to the requirement and no injury results, but as population increases and therewith not only an increase of organic wastes but also greater proportionate demand for an abundant supply of pure water for domestic and manufacturing purposes, the problems become of such magnitude and the interests so diverse, that individual cities are unable to cope with them and must look to the state for advice, relief and protection.

The present conditions in the Illinois river valley, with some notable exceptions, can not be regarded as excessively bad, but the rapid growth referred to can lead to but one result unless scientific knowledge and good business methods intervene and direct the disposal of domestic and manufacturing wastes in such a manner that nature's conversion thereof to harmless substances may be prompt and complete without creating objectionable gases or other dangerous substances.

Scientific research has demonstrated the possibility of complete reduction of organic wastes to harmless inorganic forms. Engineering has done much in the way of devising suitable appliances for carrying into effective, economical working form these forces of nature

which science has discovered. Indeed many thoroughly satisfactory works have been put into successful operation, but a process requiring less expense for installation and operation, equal or greater in efficiency, will yet be discovered.

THE ILLINOIS RIVER, THE ANCIENT OUTLET OF LAKE MICHIGAN.

The following terse statement of the conditions showing the Illinois river to be the ancient outlet for the three great lakes, Michigan, Huron and Superior, is given by Leverett,—"Water Resources of Illinois." A study of the formation of the Illinois river valley proves to be one of the most interesting subjects for geological investigation and the advance made during the last ten years has practically settled many of the questions involving the origin and development of this great valley as it now exists.

"The Southwestward or 'Chicago Outlet' of Lake Michigan, as pointed out some years since by Col. James H. Wilson and William Gooding, C. E.,[1] by Dr. H. M. Bannister,[2] and by Dr. Edmund Andrews,[3] entered the present Des Plaines Valley immediately west of Chicago and passed thence down to the Illinois. The effect of this outlet upon the size of both the Des Plaines and the Illinois is very marked. The upper portion of the Des Plaines down to the point where the ancient stream entered the valley is a small channel, 20 to 30 feet in depth and scarcely one-eighth mile in width, cut into the soft deposits of glacial drift. Upon entering the outlet the stream finds a valley more than a mile in average width, and cut to a depth of 50 to 100 feet or more, the depth varying with the altitude of bordering uplands. The excavation is mainly in drift, but for a few miles above Joliet it extends 25 feet or more into the rock.

"The Illinois flows for a few miles in a low drift basin lying west of the Marseilles moraine, in which the ancient stream was expanded into a lake which built beaches instead of eroding a channel, but from the Marseilles moraine onward a large valley is cut, having an average depth of more than 100 feet and a width of about 1½ miles throughout the new course above Hennepin and nearly 3 miles in the old part of the valley below that town.

"To appreciate how small a part of this excavation on the Illinois is due to the present drainage lines, one has only to turn to such tributaries as the Fox and Vermilion rivers and compare the small channels cut by them with the large valley of the upper Illinois, for they are all cut to about equal proportions in the drift and in rock formations of similar kind. Fox river, which includes about one-fourth of the present drainage of the upper Illinois, has in its lower 75 miles a channel with about one-eghth the width and one-half the average depth of the upper Illinois, and is even better favored than the Illinois in its rate of descent. Instead of 25 per cent of the amount of excavation displayed by the Illinois, this stream has accomplished scarcely one-fourth that amount. It seems probable that at least three-fourths of the excavation of the upper Illinois, and even more

1 Report U. S. Army Engineers, 1868, p. 442.
2 Geology of Illinois, vol. 3, 1868, pp. 240-242.
3 Trans. Chicago Acad. Sci., vol. 2, 1870, pp. 1-23.

of the portion of the Des Plaines occupied by the lake outlet, was accomplished by some ancient stream. In the lower Illinois, where the ancient stream worked entirely upon the loose materials of the drift, the excavation was larger in amount, and the valley presents a remarkably low gradient—so low that the present stream is silting up instead of eroding its bed. The fall of the stream in its lower 225 miles is but 30 feet. Whether this very low gradient is entirely due to the lake outlet or has been brought about in part through a warping of the valley has not been determined. It is certain, however, that the valley was opened throughout its entire course to a far greater extent than the present stream could have accomplished."

DRAINAGE BASINS OF ILLINOIS.

"The Mississippi receives probably three-fourths of the drainage of Illinois, mainly through the Rock, Illinois and Kaskaskia rivers. The Wabash and Ohio receive nearly all of the remaining fourth, there being but a very small part of the State tributary to Lake Michigan."

ILLINOIS RIVER DRAINAGE BASIN.

"Of the streams which traverse Illinois, the Illinois is by far the largest, its drainage area being fully half as great as the area of the State and lying mainly within the State's boundaries. The drainage area of the Illinois is estimated by Greenleaf, in his report for the Tenth Census, to be about 29,000 square miles. The estimate made by the Chicago Drainage Commission reduces it to 27,914 square miles. This area is distributed in three states, of which the proportion in each state is estimated by Greenleaf as follows: Illinois, 24,726 square miles; Wisconsin, 1,080 square miles; Indiana, 3,207 square miles. The drainage areas of the chief tributaries, given in order from source to mouth, also estimated by Greenleaf, are as follows:

Drainage areas of the chief tributaries of the Illinois River.

Stream.	Square miles.	Stream.	Square miles.
Des Plaines River	a 1,758	Mackinaw River	1,182
Kankakee River	b 5,302	Crooked Creek	1,286
Fox River	2,697	Sangamon River	5,592
Vermilion River	1,413	Macoupin Creek	1,000
Spoon River	1,905		

a The Chicago Drainage Commission estimates this area as 1,392 square miles.
b Estimated by the Chicago Drainage Commission as about 5,146 square miles.

"The drainage area or watershed of the Illinois extends in a broad band, averaging 100 miles in width, in a northeast-southwest direction directly across the center of the State. From the northeastern extremity of this band there are two projections—one north into Wisconsin, including the Fox and Des Plaines river basins; the other east into Indiana, including the Kankakee and its main tributary,

the Iroquois. The name Illinois is applied to the river from the junction of the Kankakee and Des Plaines. The western side of the watershed is 20 to 40 miles in width, while the eastern side is 60 to 80 miles.

"The Illinois river is a stream showing marked contrasts in the rate of fall. From the junction of the Des Plaines and Kankakee westward for 50 miles, being in a new course, its bed usually on the rock, it has an average fall of about 1 foot per mile; but in the remainder of its course to the Mississippi, a distance of about 225 miles, it is in a pre-glacial channel and has, as previously stated, a very slight fall.

"*DesPlaines River*—The DesPlaines is a stream with moderate descent from its source to a point near the line of Cook and Will counties, a few miles southwest of Chicago: where it begins a rapid descent. It makes a fall of about 70 feet in 8 miles, when just below Joliet it reaches a pool known as Joliet Lake, which continues nearly to its mouth."

"*Kankakee River*—The Kankakee, for about 90 miles from its source, flows through a great marsh and descends scarcely 100 feet; but in the lower 50 miles of its course it descends about 135 feet over a rocky bed. Notwithstanding this rapid descent, the lower course of the river is not subject to disastrous floods, the rise above the ordinary stage being seldom more than five or six feet. The flow is equalized to some extent by the marsh in its upper section and by sand deposits which border the lower course and receive much of the surplus water from the tributaries."

"*Fox River*—This river has a length of about 130 miles, and drains a tract 15 to 30 miles in width. In the upper half of its course it winds about sluggishly through sloughs, marshes and lakes, in the midst of a great system of moraines; in the lower half of its course it is a rapid stream. From the vicinity of Elgin to its mouth its bed is usually in the rock. The fall in its passage through Kane and Kendall counties is about three feet per mile, but in LaSalle county it increases to about 5 feet per mile, making a descent of nearly 125 feet in the lower 25 miles of its course. In its upper course tributaries are small and the flow is somewhat regular, but in the lower course several tributaries are received from a district in which slope and structure favor rapid run off, and these produce the high stages of the river, sometimes reaching 10 or 15 feet above the normal."

"*Illinois-Vermilion River*—Vermilion river has a length of about 75 miles and drains a till plain perhaps 20 miles in width. This plain descends with the stream northwestward, so that for 50 miles scarcely any valley is formed, though there is a descent of nearly 100 feet. In the lower 25 miles the stream corrades rapidly, making a descent of about 150 feet and cutting its valley mainly in rock. This stream is subject to great variations in water height. It has not the marshy gathering ground of the tributaries just considered, and the drift formations in its basin are mainly of compact till which yields but little water in seasons of drought."

"*Spoon River*—Spoon river and Crooked creek; the main tributaries of the Illinois, have valleys cut mainly in drift, but exposing rock at many points along the base of the bluffs. They probably follow approximately lines of pre-glacial drainage throughout much of their courses, but are not strictly coincident with such lines. The rate of fall is more regular than in the tributaries just described. Spoon river in the lower 80 miles of its course, south from Stark county, descends from 2 to three feet per mile. Crooked creek is nearly as regular in the lower 50 miles of its course, though more rapid. In the headwater portions of both these streams the descent is more rapid than in the lower courses, thus reversing the habit of the upper tributaries of the Illinois. Both streams are subject to great variations in water stages because of rapid run-off. The rapidity of run-off is due to rapid fall and the generally well drained surface In seasons of drought springs along the valleys and main tributaries afford a considerable supply of the water."

"*Mackinaw River*—This river drains a somewhat elevated plain in northern McLean county, standing 300 to 350 feet above the Illinois. In its middle course in Tazewell county it breaks through a moraine, and there only has it excavated a valley of much depth. In the lower 20 miles it winds about the Illinois valley in a shallow channel, making a descent of about 75 feet. This stream is one of the most variable in the State in quantity of water, being subject to great floods in wet seasons and becoming nearly dry in seasons of drought. The variability is due to several causes, rapid fall, compact drift beds, and absence of head water marshes being the principal ones."

"*Sangamon River*—Extensive plains in central Illinois are somewhat inadequately drained by the Sangamon river, whose tributaries do not ramify as thoroughly as is necessary for good drainage, and the area given as its catchment basin represents not that actually drained, but that which may, by extensive ditching, be drained into it."

The length of the river is about 180 miles. It rises in the morainic ridges of McLean county, at an altitude of about 850 feet above tide, or over 400 feet above its mouth (the mouth being 429 feet). In the first 10 miles it makes a descent of 120 feet, thus leaving 300 feet of fall for the remaining 170 miles of its course. The fall is far from regular, there being sections often several miles in length in which it is slight, between which are sections with more rapid fall. Thus in its course through Sangamon county, a distance of 36 miles, it falls only 38 feet, while in crossing Menard county, immediately below, it falls 67 feet in a distance of 30 miles, and in crossing Macon county, just above Sangamon, it falls 50 feet in about 30 miles. In the lower 23 miles, where it crosses the Illinois bottoms, its fall is only 16 feet.

This river in seasons of drought reaches a very low stage, becoming almost dry. The till plain which it drains yields very little water to the streams except immediately after rains have fallen. Freshets now seldom last more than a few days, and are said to be much briefer than before the district was brought under cultivation.

"*Macoupin Creek*—Macoupin creek, Apple creek, and other small tributaries of the lower Illinois show a rapid descent, their head waters being nearly 300 feet above the Illinois. They traverse a district in which drainage lines ramify through nearly every section. The drift being largely a compact till, rainfall is absorbed slowly. These streams therefore carry off a large amount of water, but in dry seasons they almost cease flowing."

CHICAGO WATER SUPPLY, SEWERAGE SYSTEM AND MAIN DRAINAGE CHANNEL.

The city of Chicago has been the great center of manufacturing enterprise, commerce and industry, not only of the State of Illinois but for the great central and western portion of our country. The natural conditions and surface configuration made it at once one of the most difficult locations on which to provide healthy habitation for man, but ease of access and nearness to the great fertile prairies of the west soon made it the port for that vast region with an ever increasing population. Natural obstacles had to be overcome, for there was no other such situation on the continent. The greatest questions of sanitation which have had to be met thus far in this State have grown out of the needs of that city which has received her due share of consideration at the hands of the State authorities. A brief history of the progress and development of the drainage and water supply of Chicago is therefore of much importance to any consideration of the sanitary condition and needs of the Illinois river valley through which its sewage flows and of which Chicago has thus been made a part.

The following brief historical account of the development of the water supply of the city of Chicago, its sewerage system and main drainage channel, which was completed and put into operation in January, 1900, is condensed from "Drainage Channel and Waterway" by G. P. Brown.

Chicago obtained its first water supply from wells dug in the sand which had been heaped up by the winds, or in the silt deposited by the receding waters of the lake. In spite of serious contamination the wells were used for 20 years after Chicago was incorporated as a village, although they were not the only source of water supply. When Chicago was a small village it was the custom, as in small villages every where today, to dig both the well and the vault on the same lot. The wells were never more than 12 feet deep, and usually 6. It is easy to understand how a very rapid and serious contamination of the well waters in Chicago was brought about when it is known that the city is built upon a bed of sand and vegetable mold underlaid with blue clay, in many cases the blue clay and the sand being in alternate layers ranging in thickness from a few inches to some feet. The sand veins would thus form natural courses for the drainage of the vaults which would flow by seepage into the wells and thus bring about the contamination referred to. Dr. A. S.

Martin, an early resident of Chicago, wrote to the Sanitary News in 1884: "The water supply was taken from wells sunk on individual premises, or on vacant lots, some times in the streets. Dish water, wash water, and all fluid refuse from the kitchen were generally thrown on the ground in back yards. In time the water drawn from the wells began to taste,—a little brackish at first, then saltish, and finally it had a perceptible odor, which ultimately became offensive. A well, at length, had the odorous characteristics of a privy vault. When it rained the water in well and privy vault rose accordingly; unless the prudent householder 'banked' the latter it often overflowed.

"The disuse of wells brought into existence a new enterprise, that of hauling water from the lake and selling it. A hogshead mounted on an axle between two wheels and drawn by a horse was first used. The only opening was a hole at the top sufficiently large to admit a pail. The vehicle was backed into the lake until the water came conveniently near the top, when the hogshead was filled by the use of pails. The driver then proceeded up the street, mounted on a cross piece in front of the hogshead, and served those who hailed him with water at a shilling per barrel. The use of the pail in emptying was finally superseded by a hose, tacked around a hole about 4 inches in diameter near the bottom. At length contracts were made and many families were supplied on certain days of each week or every other week."

On Nov. 10, 1834, the village council of Chicago appropriated $95.50 for digging a public well at the corner of Cass and Michigan streets. This was the first official action taken by this municipality for a public water supply. This well supplied only a small colony on the North side; persons living on the South side continued to draw water from their individual wells, or to buy it from the water purveyors. Water was taken from the lake at the foot of Van Buren street, and supplied by carts as late as 1846. The owners of water carts had a lucrative business and organized a company. As the lake was often tempestuous and it was impossible to fill the water carts, dissatisfaction and hardship among the inhabitants prepared the way for a pumping system. The Chicago Hydraulic Company was incorporated by special act of the Legislature in January, 1836, and the works were established in 1840. An inlet pipe was laid on a cribwork foundation and extended out into the lake about 500 feet. The pipe was of cast iron, about 15 inches in diameter. At the shore end was a tank with a capacity of five or six hundred barrels, raised above the ground a few feet by a block foundation. This slight elevation created the only pressure in the distributing system. The works were equipped with a 25-horse power engine and pump to draw the water from the lake to the reservoir; about two miles of rude wooden pipe were laid. The mains were six inches in diameter and were laid in the alleys about three feet below the surface. The sections of the pipe were pine logs, bored out by hand and strapped with hoop iron.

This primitive system supplied only a limited portion of the south division with water. Notwithstanding its apparent advantages, it is

said that at least four-fifths of the people living within the corporate limits obtained their water for domestic use from the river or by water carts from the lake.

The Chicago Hydraulic company does not appear to have made money out of its venture but it maintained an existence until Feb. 15, 1851, when the Legislature, again by special act, incorporated the Chicago City Hydraulic company.

In 1854 the city of Chicago put into operation its own water works system, having purchased the rights of the Hydraulic company. This was the beginning of the present system. Authority over the works was vested in a Board of Water Commissioners. The pumping works were located on the lake shore at the foot of Chicago avenue. Already the discharge of sewage into the lake from the river had caused annoyance and an alternative location for the pumping works at a considerable distance south of the Chicago river was suggested, but it was not considered of sufficient moment to change the location from that given above. The water was taken from an inlet basin on the lake shore, separated from the lake by a semi-circular break-water with an opening to the southeast, and distributed through three reservoirs situated, respectively, at LaSalle and Adams streets, Chicago avenue and Sedgwick street, and Morgan and Monroe streets. To keep the three reservoirs filled it was necessary to operate the pumps about 12 hours a day. The use of these reservoirs was discontinued after the completion of the west side tunnel in 1874.

In a sketch of the water supply system, written in 1876, Chief Engineer Chesbrough says that the increased growth of the city after the inauguration of the water works, and the introduction of sewerage, together with the establishment of the packing houses, distilleries, etc., so increased the quantity of filth discharged into the lake that complaints began to be made of impurity and offensiveness in the supply from the pumping works.

The first tunnel for taking water from a crib located at some distance from the lake shore was completed Dec. 6, 1866. This tunnel was 10,567 feet long, 5 feet across, and 5 feet 2 inches high, and cost $380,784.60. After the completion of this tunnel the water supply was satisfactory for a number of years. In later years additional tunnels extending further into the lake have been constructed but the encroachments of the increased quantity of sewage have been a continued menace to the purity of the water supply.

THE SEWERAGE SYSTEM.

No effort was made to provide Chicago with a system of sewerage until the year 1855. Previous to that time the city was drained by submerged wooden boxes on a few of the principal streets These were constructed, primarily, to supply water for use in extinguishing fires. They were found to be serviceable in carrying away surplus water from the streets, and were afterwards used to a limited extent for house drainage. As they were laid without system and were limited in capacity they were of littte use except for surface drainage. In wet seasons they failed to carry away even the surface water.

As a result the city was scourged by epidemics for six years in succession. The death rate became higher than that of any other city in the country. In 1854, with cholera raging, nearly 5½ per cent of the population died. For the six years beginning with 1849 and ending with 1854, the death rate was 48.92 per thousand. In self defense the city was compelled to consider the construction of an adequate sewerage system. A bill was passed by the Legislature on February 4, 1855, creating a Board of Sewerage Commissioners to be appointed by the City Council. The first Board consisted of William B. Ogden, J. D. Webster and Sylvester Lind, one from each division of the city. E. S. Chesbrough, then of Boston, was appointed chief engineer. The remainder of the first year was spent in making surveys and preparing plans, which were adopted in December. Work was begun on the sewers in the spring of 1856.

Summarized, the Act creating the commission made these provisions: (1). It shall be the duty of the commissioners to examine and consider all matters relating to the thorough, systematic and effectual drainage of the city of Chicago, not only of surface water and filth, but also of the soil to a sufficient depth to secure dryness in cellars and an entire freedom from stagnant water, and in such a manner as best to promote the healthfulness of the city. (2). It shall be the duty of the commissioners, before entering upon the construction of any sewer, to fix upon a plan or system of sewerage of such a nature that all subsequent sewers may be executed upon that plan. (3). It shall be the duty of the board to prescribe the location, arrangement, form, material and construction of every private drain or sewer emptying into the public drains or sewers, and determine the manner and plan of such connection. (4). It shall be the duty of the board to see that the proper drains or sewers are constructed from every lot in the city, which, in their judgment, requires it, and that such private drains or sewers are made to communicate with public drains or sewers in a proper manner and they shall have power to require such number of drains or sewers to be thus constructed as they shall deem expedient.

Systematic sewerage in this country was unknown when Mr. Chesbrough was called upon to suggest the best method of complying with the law. Not only was the chief engineer unable to profit by the experience of other cities, but the local conditions were unfavorable. From a sketch written by Mr. W. H. Clarke, principal assistant engineer in 1877, it is learned that when the original surveys for the sewerage system were made, the surface of the ground in the vicinity of the North and South branches of the Chicago river was only three or four feet above the surface of the lake. It rose irregularly eastward, until at Michigan and Rush streets it was from ten to twelve feet above the same level; to the westward it reached about the same level at Ashland avenue. This configuration made it necessary to raise the grade of the streets to keep the sewers under ground. After considerable discussion it was decided to fill in to a level of ten feet above ordinary water on the streets adjacent to the river, raising them with an inclination sufficient to protect the sewers and to permit the construction of cellars seven to eight feet in height. A higher grade wss recommended, but it was argued that there would

RAISING THE STREETS

be difficulty in securing sufficient earth to raise the streets to the minimum height decided upon. A few years later it was found that the surplus earth of the South division was sufficient not only to raise the grade of the streets but to fill up the entire lake basin between the Illinois Central railroad and Michigan avenue. For a number of years after the construction of the sewers began, some of them were partially above ground, and others entirely so, in what are now business districts of the city. In other localities where the ground was high enough to cover the sewers the grades of the street were fixed by cutting out abrupt irregularities. In places where the ground was too low to permit construction of well drained cellars the grade was established at such a height above the surface of the lake as to give not less than seven feet in height to the cellars if they were entirely below the surface of the ground, and at a greater height if the principal floor was elevated above the level of the street.

Soon after their organization the sewerage commissioners asked the public for plans and suggestions. Thirty nine communications were received. Some of them according to Mr. Chesbrough, were very able and interesting papers. Although none of the plans proposed were adopted, there were many valuable suggestions. Mr. Chesbrough's report to the commissioners was made on December 26, 1855. The plan he proposed was adopted by the board on December 31. It provided for the discharge of the sewage mainly into the river, which, the chief engineer argued, would deliver it well out into the lake. The general arrangement of the sewers placed mains in each of the alternate streets running to the river, or about 800 feet apart, into which two foot brick sub-main sewers in the streets running at right angles were to discharge. The main sewers were from three to six feet in diameter and built of brick, the walls being eight and one-half inches thick.

The minds of the people were still unsettled as to what should be admitted to the sewers. Sewers were originally constructed to carry off surface water only. Bazalgette says of London sewerage: "Up to the year 1815, it was penal to discharge sewage or offensive matter into the sewers. Cesspools were regarded as the proper receptacles for house drainage, and sewers as the legitimate channels for carrying off the surface water only. Afterwards it became permissive, and in the year 1847 the first act was obtained making it compulsory to drain houses into sewers."

As the main object of sewers was to improve and to preserve the health of the city, it was obvious to Mr. Chesbrough that all substances should be received into them which wonld have a contrary effect if not drained off. Four principal plans had been proposed: (1.) Into the river and branches directly, and thence into the lake. (2.) Directly into the lake. (3.) Into artificial reservoirs, to be thence pumped up and used as a fertilizer. (4.) Into the river, and thence by a steamboat canal into the Illinois river. The first plan had been adopted. The reasons in its favor were that it would allow the sewers to be constructed in such a manner as to take the utmost advantage of the natural facilities that the site of the city afforded, and, consequently, that the sewerage might be less in extent and cost.

His objections to draining directly into the lake were: (1) The greater length of sewers required, and consequently greater cost; (2) The difficulty in stormy weather of protecting the outlets from injury, or from being obstructed by sand and ice; (3) The supposed effect on the water with which the citizens were supplied from the lake, if any of the outlets should be near the pumping engine. From this it would appear that Mr. Chesbrough did not anticipate that the sewage discharged into the lake from the river could by any possibility ever reach the inlet of the water supply.

"The objections to draining the sewage into reservoirs and then pumping it up to be used for agricultural purposes, were: (1) The great uncertainty about a demand for the sewage after it was pumped up sufficient to pay for distributing it; (2) The great evil that would necessarily result from a failure of the reservoirs through insufficiency of capacity, especially if the system of sewers leading to them should have their outlets too low to empty into the river or lake. If the reservoirs should be made so large as to place them beyond all doubt of sufficient capacity, they would be very expensive, both on account of labor and materials required in their construction, and the ground they would occupy; (3) There would be danger to the health of the city during the prevalence of winds from the quarter in which the sewage might be distributed, especially if only a few miles distant, and spread over a wide surface.

"With regard to the fourth plan, or draining into the proposed steamboat canal, which would divert a large and constantly flowing stream from Lake Michigan into the Illinois river," said Mr. Chesbrough, "it is too remote a contingency to be relied upon for present purposes; besides, the cost of it, or any other similar channel in that direction, sufficient to drain off the sewage of the city, would be not only far more than the present sewerage law provides for, but more than would be necessary to construct the sewers for five times the present population. Should the proposed steamboat canal ever be made for commercial purposes the plan now recommended would be about as well adapted to such a state of things as it is to the present, making it necessary to abandon only the proposed method of supplying the south branch with fresh water from the lake, and to pump up from the new canal, or draw from the DesPlaines directly flushing water from the west district, instead of obtaining it from the present canal at Bridgeport, as herein recommended."

In order to maintain a constant current and flow of fresh water in the Chicago river, canals from the lake were proposed to supply both the North branch and South branch. These, however, have never been constructed, the Fullerton avenue conduit having been constructed to supply fresh water to the North branch and the drainage of the South branch having been turned westward to the Illinois river.

CHICAGO MAIN DRAINAGE CHANNEL.

The "Drainage Canal," as it is popularly known, was opened January 17, 1900, for use as the main sewer of Chicago, leading from Lake Michigan across the Chicago divide between the present watersheds of the St. Lawrence and the Mississippi rivers and discharging the sewage of Chicago with its dilutent of Lake Michigan water into the DesPlaines, thence to the Illinois river.

This great sewer has beea made possible only by its advantages as a commercial waterway, connecting two of the greatest navigable river and lake systems in the world, and every project for drainage of Chicago into the Illinois which has not recognized the waterway features has been predestined to failure.

When the sewerage system of Chicago was first contemplated the design was with reference to the then presumedly remote possibility of a ship canal across the divide which could be used for the outlet of the sewage and thus protect the lake, from which the public water supply was then, as now, taken.

The earliest mention of a ship canal across the Chicago divide bears the distinction of coming from Joliet who first explored the Illinois Valley in 1673. The next explorer of note, LaSalle, did not regard the project as feasible and unto this day there are "Joliets" and "LaSalles," notwithstanding the fact that since 1848, 53 years ago, the Illinois and Michigan canal has been in service and now that approximately one-half of the greater water-way has been completed and the entire cost practically charged to the account of the water supply of the city of Chicago. Were it not for the contamination of her water supply Chicago's sewage would still be flowing lakeward.

The construction of the Illinois and Michigan canal was begun in 1836 and it was completed on the shallow cut plan in 1848. The contract for deepening the canal summit level was let in 1865 but the work was not begun until two years later and completed in 1871. This deepening created a gravity flow from Lake Michigan to the Illinois river estimated at 33,000 cubic feet per minute and renewed the water of the South Branch of the Chicago river so thoroughly that the cleansing of that portion of the river was very satisfactory.

The old pumps which had been used to pump water from the river for the summit level of the canal were operated by arrangement between the canal commissioners and the city to effect a flow in the South Branch, thereby assisting in cleansing it much of the time for the six years from 1866 to 1871. In 1873 these pumps, being regarded as of no more use, were sold. As the city grew the sewage increased and by reason of precipitation of the solids carried in the sewage the capacity of the canal was reduced until in 1879 the flow was estimated at 10,000 to 17,000 cubic feet per minute depending upon the varying height of the lake which is affected greatly by the winds and seasons. In 1884 pumping works were rebuilt by the city at Bridgepoart for the drainage of the Chicago river and operated until the opening of the new drainage canal Jan. 17, 1900.

The amount of sewage pumped over at Bridgeport has been variously estimated at 35,000 to 50,000 cubic feet per minute and it is probable that the lower figure is nearer correct, so that further on in this report 36,000 cubic feet per minute, 600 feet per second, has been taken as the average for the ten years, 1890 to 1899 inclusive. The greatest concern of the residents and officials of the city of Chicago, from about 1860, when the river became an unbearable nuisance, to about 1880, was to improve the condition of the river. True, it was recognized by some that the water supply was at times contaminated with sewage, but the greater stress was laid upon the evil odors and appearance of the river. The slaughtering and packing industries in those days produced, or wasted, much more refuse than at the present time, so that the condition of the south branch in those days had to be seen and smelled to be appreciated.

The tendency of all these years was, therefore, toward a canal which would drain the refuse of Chicago to the Illinois, carrying with it sufficient lake water to so dilute the contents of the Chicago river as to make it unobjectionable. The capacity of the Illinois and Michigan canal having been very soon exceeded, the steps which made the canal of today possible were taken when in May, 1889, the Illinois Legislature enacted the Sanitary District Law. Under this law the Chicago sanitary canal has been constructed from Robey street, Chicago, through Joliet, Illinois, and made a navigable waterway, 22 feet deep and 160 feet wide as far as the controlling works at Lockport, a distance of a little more than thirty miles from Lake Michigan, including six miles of the Chicago river, which is not so deep and wide. The Chicago river has also been widened and deepened, but much work remains to be done there before the interests of navigation and sanitation will be harmonized.

POPULATION OF ILLINOIS AND OF THE ILLINOIS RIVER BASIN.

The population of Illinois at each census from 1810 to 1900, inclusive, together with the increase by number and per cent during each decade is given in the following table:

POPULATION OF ILLINOIS, 1810 TO 1900.

Census Years.	Population.	Increase.	
		Number.	Per cent.
1900	4,821,550	995,199	26.0
1890	3,826,351	748,480	24.3
1880	3,077,871	537,980	21.1
1870	2,539,891	827,940	48.3
1860	1,711,951	860,481	101.0
1850	851,470	375,287	78.8
1840	476,183	318,738	202.4
1830	157,445	102,283	185.4
1820	55,162	42,880	349.1
1810	12,282	....	....

From this table, which has been prepared by the Census Bureau, it will be observed that the population of the State in 1900 is 4,821,550, as compared with a population in 1890 of 3,826,351, showing an increase during the last ten years of 995,199, or 26 per cent. This is a greater rate of increase than that for any decade since 1870, and a greater numerical increase than that for any decade in the history of the State. Prior to 1870 the growth of the State was very rapid, and the rate of increase was much greater than it has since been.

The present population of the State is more than 392 times as great as the population reported for 1810, the first census taken after its organization as a territory in 1809.

The following table, also from the Census Bulletin of 1900, shows the

INCREASE IN POPULATION OF ILLINOIS BY COUNTIES, 1890 TO 1900.

Counties.	Increase.		Counties.	Increase.	
	Number.	Per cent.		Number.	Per cent.
The State	995,199	26.0	Lawrence	1,830	12.4
			Lee	3,707	14.1
Adams	5,170	8.3	Livingston	3,580	9.3
Alexander	2,821	17.0	Logan	3,191	12.5
Bond	1,528	10.5	Macon	5,920	15.5
Boone	3,588	29.4	Macoupin	1,876	4.6
Brown	*394	*3.2	Madison	13,159	25.5
Bureau	6,098	17.4	Marion	6,105	25.0
Calhoun	1,265	16.5	Marshall	2,717	19.9
Carroll	643	3.5	Mason	1,424	8.8
Cass	1,259	7.8	Massac	1,797	15.8
Champaign	5,463	12.9	McDonough	945	3.4
Christian	2,259	7.3	McHenry	3,645	13.9
Clark	2,134	9.7	McLean	4,807	7.6
Clay	2,781	16.5	Menard	1,216	9.2
Clinton	2,413	13.8	Mercer	2,400	12.9
Coles	4,053	13.4	Monroe	899	6.9
Cook	646,813	54.2	Montgomery	833	2.7
Crawford	1,957	11.3	Morgan	2,370	7.2
Cumberland	681	4.4	Moultrie	743	5.1
DeKalb	4,690	17.3	Ogle	419	1.4
DeWitt	1,961	11.5	Peoria	18,230	25.9
Douglas	1,428	8.0	Perry	2,301	13.1
DuPage	5,645	25.0	Piatt	644	3.7
Edgar	1,486	5.5	Pike	595	1.9
Edwards	901	9.5	Pope	*431	*3.0
Effingham	1,107	5.7	Pulaski	3,199	28.1
Fayette	4,698	20.1	Putnam	16	0.3
Ford	1,324	7.7	Randolph	2,952	11.7
Franklin	2,537	14.8	Richland	1,872	9.1
Fulton	3,091	7.1	Rock Island	13,332	31.8
Gallatin	901	6.0	Saline	2,343	12.1
Greene	*389	*1.6	Sangamon	10,398	16.9
Grundy	3,112	14.8	Schuyler	116	0.7
Hamilton	2,397	13.4	Scott	151	1.4
Hancock	308	0.9	Shelby	935	2.9
Hardin	214	2.9	Stark	204	30.2
Henderson	960	9.7	St. Clair	20,114	2.0
Henry	6,711	20.1	Stephenson	3,595	11.4
Iroquois	2,847	8.0	Tazewell	3,665	12.4
Jackson	6,062	21.7	Union	1,061	4.9
Jasper	1,972	10.8	Vermilion	15,730	31.5
Jefferson	5,543	24.5	Wabash	717	6.0
Jersey	*198	*1.3	Warren	1,882	8.8
JoDaviess	*568	*2.2	Washington	264	1.3
Johnson	654	4.3	Wayne	3,820	16.0
Kane	13,731	21.1	White	381	1.5
Kankakee	8,422	29.3	Whiteside	3,856	12.4
Kendall	*639	*5.2	Will	12,757	20.5
Knox	4,860	12.5	Williamson	5,570	25.0
Lake	10,269	42.3	Winnebago	7,907	19.7
LaSalle	6,978	8.6	Woodford	393	1.8

* Decrease.

"There have been no territorial changes in the counties of Illinois since 1890.

"Of the 102 counties in the State all but 6 have increased in population during the decade, the counties showing the largest percentages of increase being Cook, 54.2 per cent; Lake, 42.3 per cent; Rock Island, 31.8 per cent; Vermilion, 31.5 per cent; St. Clair, 30.2 per cent; Boone, 29.4 per cent; Kankakee, 29.3 per cent, and Pulaski, 28.1 per cent.

"The 6 counties showing a decrease are Brown, Greene, Jersey, Jo Daviess, Kendall, and Pope."

Chicago, the great city of the central west, shows the most wonderful growth of any city in the United States. In 1840 the population of Chicago was 4,470. From that time the increase has been continuous and very rapid. In 1850, 29,963; in 1860, 109,260; in 1870, 298,966; in 1880, 503,185; in 1890, 1,099,850; in 1900, 1,698,575. In the State there are six other cities having a population of more than 25,000: namely, East St. Louis, 29,655, which nearly doubled in population in the last decade; Joliet, 29,353; Peoria, 56,100; Quincy, 36,252; Rockford, 31,051; Springfield, 34,159. In addition to the 56,100 in Peoria June 1, 1900, the village of North Peoria, with 2,358 inhabitants has been annexed since that time, making a total of 58,458 inhabitants now in the city of Peoria. The total population in the State of Illinois, including Chicago, residing in cities of more than 25,000 inhabitants is 1,915,145, which is 40 per cent of the entire population of the State. The population residing upon the drainage of the Illinois river and the various sub-basins thereof is shown in the following table, which has been compiled from the United States Census reports of 1890 and 1900. This table shows the population divided into two classes called urban and rural. The former class includes all population residing in villages and cities of 1,000 inhabitants and more. The latter includes all others. This distinction has been made in this report because all villages and cities of 1,000 population and more are either now provided with public water supply and sewerage systems or will be in the not very distant future. Villages having a population of less than 1,000 seldom have public water supply or sewerage systems and the compilation of the population statistics is for the purpose of getting a better comprehension of the growing demand for abundant supplies of pure and wholesome water for domestic purposes as well as facilities for the disposal of sewage.

The map of Illinois which accompanies this report has been prepared to show (1) the drainage basin of the Illinois river and dividing lines of the sub-basins; (2) the location of cities and villages of 1,000 or more population, and their growth during the two decades just past—the circles being drawn to scale to represent the population according to the United States Census for the years 1880, 1890 and 1900. The location and density of urban population is thus seen by a glance at the map. The Illinois river basin covers about half of the entire State and includes the major portion of the population outside of Chicago.

Illinois River Drainage Basin Recapitulation Table—Population Various Sub-Basins.

Drainage Basin.	Total Population 1890.			Total Population 1900.			Numerical Increase.			Per Cent. Increase.		
	Urban.	Rural.	Total.	Urban.	Rural.	Total.	Urban.	Rural.	Total.	Urban.	Rural.	Total.
*Des Plaines	49,355	51,541	100,896	70,748	54,107	124,855	21,393	2,566	23,959	43.3	5.0	23.8
Du Page	5,344	13,978	19,322	6,851	14,853	21,704	1,507	875	2,382	28.3	6.3	12.3
*Kankakee	35,450	143,263	178,713	44,681	147,545	192,226	9,231	4,282	13,513	26.5	3.0	7.6
*Fox	69,166	93,562	162,728	81,743	93,610	175,353	12,577	48	12,625	18.2	0.05	7.8
Vermilion	21,085	42,227	63,312	27,631	40,970	68,601	6,546	—1,257	5,289	31.0	—3.0	8.4
Mackinaw	8,781	35,407	44,188	10,924	36,372	47,296	2,143	965	3,108	24.4	2.7	7.0
Spoon	22,056	53,322	75,378	28,519	53,263	81,782	6,463	—59	6,404	29.3	—0.1	8.5
Sangamon	101,585	173,105	274,690	133,632	169,464	303,096	32,047	—3,641	28,406	31.6	—2.1	10.3
Crooked Creek	11,853	43,550	55,403	14,344	40,230	54,574	2,491	—3,320	—829	21.0	—7.6	—1.5
McKee's Creek	5,238	11,943	17,181	5,624	10,317	16,461	386	—1,106	—720	7.4	—9.4	—4.2
Macoupin Creek	13,023	32,535	45,558	15,778	30,584	46,362	2,755	—1,951	804	21.2	—6.0	1.8
Pop. Directly Trib. to Illinois	139,134	193,841	332,975	177,189	201,888	379,077	38,055	8,047	46,102	27.4	4.1	13.8
Totals	482,070	888,274	1,370,344	617,664	893,723	1,511,387	135,594	5,449	141,043	28.2	0.61	10.3

—Indicates Decrease.

*Census for Indiana and Wisconsin in 1900 not at hand, and that of 1890 used.

The Illinois River Basin Areas—Population for 1890 and 1900, and Per Cent. of Increase.

TRIBUTARY.	Area.	Total Area.	Distance Miles.	1890.	1900.	Per Cent of Increa'e.
†Des Plaines River	1,392	....	00.0	120,218	*146,559	21.8
Kankakee River	5,146	6,538	00.0	178,713	*192,226	7.5
Smaller Tributaries	991	7,529	....	38,081	42,943	12.79
Fox River	2,700	10,229	33.1	162,728	*175,353	7.70
Smaller Tributaries	136	10,365	....	41,779	45,402	8.68
Vermilion River	1,317	11,682	46.2	63,312	68,601	8 35
Smaller Tribs—Peoria and above	1,797	13,479	112.1	99,410	126,758	27.58
Smaller Tributaries below Peoria	352	13,831	....	24,138	26,246	8.00
Mackinaw River	1,217	15,048	121.0	44,188	47,296	7.05
Smaller Tributaries	536	15,584	....	16,547	17,457	5.50
Spoon River	1,870	17,454	151.6	75,378	81,782	8.54
Smaller Tributaries	140	17,594	....	16,340	17,283	5.77
Sangamon River	5,670	23,264	174.1	274,690	303,096	10.33
Smaller Tributaries	180	23,444	....	13,070	14,194	8.60
Crooked Creek	1,385	24,829	188.3	55,403	54,574	−1.48
Smaller Tributaries	290	25,119	....	9,620	10,153	5 55
McKee's Creek	472	25,591	205.7	17,181	16,461	−4.20
Smaller Tributaries	1,185	26,776	....	67,296	62,248	−0.75
Macoupin Creek	985	27,761	248.6	45,558	46,362	1.76
Smaller Tributaries	153	27,914	....	7,125	5,867	−1.77
Totals	27,914	....	....	1,370,344	1,511,387	10.3

* Census for Indiana and Wisconsin in 1900 not at hand and that of 1890 used.
† Du Page included herein as part of Des Plaines.
— Indicates decrease.

The above table not only shows the urban, rural and total population on the various river basins tributary to the Illinois in 1890 and 1900, but also shows the numerical percentage of increase of each as well as of the whole region. It will be noted that the greatest increase of urban population has been upon the Des Plaines Valley, which is adjacent to the city of Chicago. The urban population in this case having increased 43.3 per cent, the rural population 5 per cent, and the total population 23.8 per cent. The increase in the entire Illinois river valley is, urban 28.2 per cent, rural .61 per cent and total 10.3 per cent. The greatest increase in rural population has likewise been upon the Des Plaines basin and the Du Page, which is in fact a part of the Des Plaines, but on account of its covering quite an extensive territory has been listed separately. The Kankakee river basin also shows an increase of rural population of 3 per cent. The Vermilion, the Spoon and the Sangamon rivers, Crooked Creek, McKee's Creek and Macoupin Creek all show a decrease in rural population under the classification which has been adopted.

Referring to the cities located upon the Illinois drainage basin we find three; namely, Peoria, Springfield and Joliet with a population of more than 25,000 and 17 with a population of between 5,000 and 25,000. The total population of these 20 cities is 333,811; the total population upon this drainage basin, 1,511,387. Hence 22 per cent of the total population of the Illinois river valley resides in cities of 5,000 and over. The following table gives the population of all the cities on the Illinois valley of 5,000 and over in 1900, also the population of the same cities in 1890.

Table of Cities Lacated on Illinois Drainage Basin Having Population of 5,000 or more in 1900.

City.	Population. 1900.	Population. 1890.	Population. Inc.	City.	Population. 1900.	Population. 1890.	Population. Inc.
Peoria	58,458	41,024	17,434	Ottawa	10,588	9,985	603
Springfield	34,159	24,963	9,196	LaSalle	10,446	9,855	591
Joliet	29,353	23,264	6,089	Lincoln	8,962	6,725	2,237
Aurora	24,147	19,688	4,459	Pekin	8,420	6,347	2,073
Bloomington	23,286	20,484	2,802	Peru	6,863	5,550	1,313
Elgin	22,433	17,823	4,610	Canton	6,564	5,604	960
Decatur	20,754	16,841	3,913	Spring Valley	6,214	3,837	2,377
Jacksonville	15,078	12,935	2,143	Pana	5,530	5,077	453
Streator	14,079	11,414	2,665	Macomb	5,375	4,052	1,323
Kankakee	13,595	9,025	4,570	* Pt. Galesburg	9,304	7,632	672

* The city of Galesburg is upon the divide between the Illinois and Mississipi river drainage basins. The total population of Galesburg in 1900 was 18,607 and in 1890 was 15,264. The number of inhabitants shown in the above table has been estimated as tributary to the Illinois.

Population of the City of Chicago.

Potulation.		Increase from 1890 to 1901.	
1890.	1900.	Number.	Per cent.
1,099,850	1,698,575.	598,752	54.4

A table showing areas in square miles and population per square mile on the various sub-basins of the Illinois river has been prepared for the purpose of showing the total and rural population per square mile and the increase or decrease, if any.

Illinois River Basin—Areas and Population per Square Mile.

Rivers.	Area Square Miles.	Tot. Pop. per Sq. Mi. 1890.	Tot. Pop. per Sq. Mi. 1900.	Tot. Pop. per Sq. Mi. Inc.	Rur. Pop. per Sq. Mi. 1890.	Rur. Pop. per Sq. Mi. 1900.	Rur. Pop. per Sq. Mi. Inc.
DesPlaines	1,392	86	105	19	47	49	2
Kankakee	5,146	35	37	2	28	29	1
Fox	2,700	60	65	5	35	35	0
Vermilion	1,317	48	52	4	32	31	−1
* Mackinaw	1,217	36	39	3	25	26	1
Spoon	1.870	40	44	4	29	29	0
Sangamon	5,670	49	54	5	31	30	−1
Crooked Creek	1,385	40	39	−1	31	29	−2
McKee's Creek	472	36	35	−1	25	23	−2
Macoupin Creek	985	45	46	1	33	31	−2
† Other territory	5,760	58	66	8	34	35	1
Total	27,914	49	54	5	31	31	0
Peoria and above. * Other territory	2,924	61	74	13	....	....	....
Total	13,479	52	59	7	....	....	....
Below Peoria. † Other territory	2,836	58	58	0	....	....	....
Total	14,435	46	52	6	....	....	....

The areas given in the above table are taken from the preliminary report of the State Board of Health, issued in 1889. From this table it will be observed that the total area of the Illinois river basin is 27,914 square miles, with a population in 1890 and 1900 of 49 and 54 per sqare mile respectively; an increase of 5 for the entire area. The rural population of the entire area is 31 per square mile both in 1890 and 1900, showing no increase nor decrease as a whole. The greatest number of inhabitants per square mile is upon the DesPlaines, being 86 in 1890 and 105 in 1900, an increase of 19 per square mile. The Kankakee shows the lowest number of inhabitants per square mile, being 35 in 1890 and 37 in 1900. It will be remembered, however, that about 25 per cent of the Kankakee river drainage basin is marsh and further that the population in 1900 of three-fifths of this basin; namely, that lying in Indiana was not at hand for this tabulation and the population of 1890 is used, so that the entire increase is that of only the Illinois territory.

As has been previously noted the population of the Des Plaines is tributary to the city of Chicago and the greater density of population together with the large increase both in percentage and inhabitants per square mile is due to the fact that this population finds employment in and about the city of Chicago. The Fox river valley shows the next largest population per square mile, being 60 in 1890 and 65 in 1900, with an increase in the decade of 5 per square mile. The territory immediately tributary to the Illinois, which includes a few of the smaller streams and the adjacent valleys, had a population of 58 per square mile in 1890 and 66 in 1900, an increase of 8 per square mile. The Vermilion, the Mackinaw, the Spoon and the Sangamon show increases in total population of from 3 to 5 per square mile, with populations ranging from 39 to 54 per square mile in 1900.

The Illinois river valley is divided for purpose of discussion at Peoria into two portions which are designated as the upper and lower valley. The Des Plaines, the Kankakee, the Fox and the Vermilion rivers and other territory directly tributary to the Illinois, amounting to 2,924 square miles, constitute the total area of the upper valley, which is 13,479 square miles. Upon this territory the population in 1890 was 52 per square mile and in 1900, 59, an increase of 7 per square mile. On that portion of the territory above Peoria which is directly tributary to the Illinois, the population in 1890 was 61 and in 1900 was 74, an increase of 13. Comparing this with the lower valley the population on the territory directly tributary to the Illinois in 1890 was 58 per square mile and the same in 1900, no increase. The entire territory of the lower Illinois had a population of 46 in 1890 and 52 in 1900, an increase of 6. This increase of the lower Illinois was upon the Mackinaw, the Spoon and the Sangamon basins.

The rural population upon the entire Illinois valley, except upon the DesPlaines, ranged from 28 on the Kankakee to 35 on the Fox in 1890 and from 29 on the Kankakee to 35 on the Fox and the territory directly tributary to the Illinois in 1900. The Kankakee, the Mackinaw and the territory directly tributary show an increase in rural

population of 1 inhabitant per square mile for the last decade, while the Vermilion and the Sangamon show a decrease of 1 each per square mile. Crooked creek, McKee's creek and Macoupin creek show a decrease of 2 inhabitants each per square mile. The Des Plaines shows an increase of 2 per square mile. The Fox, the Spoon and the entire territory show no change in density of rural population.

A review of the foregoing table of the population per square mile comparing the total with the rural, will show where the manufacturing activity of the State exists; namely, upon the DesPlaines, the Fox, to some extent upon the Sangamon, and directly upon the Illinois river as far down as Peoria, there being no growth in population per square mile below that point.

Later in this report under the discussion of water supply statistics, will be found a table which gives the urban population in 1890 and 1900 and the per cent which the urban population is of the entire population upon the various sub-basins. The average for the entire area was 35 per cent in 1890 and 41 per cent in 1900; the lowest is 23 per cent on the Kankakee and the Mackinaw; the highest is 57 per cent on the DesPlaines. The Fox and the Illinois direct each show 47 per cent and the Sangamon 44 per cent, all being above the average percentage of urban population. This table, in connection with the foregoing table of population per square mile, sets out very clearly the location and the effect of manufacturing interests upon the density of population. The rural population, as seen heretofore, having remained substantially constant during the decade.

The following tables give, in detail, the urban and rural population by counties and by drainage basins.

Population for 1890 and 1900, of Counties on the Illinois River Drainage Basin.

County—City.	1890.			1900.		
	Urban Pop.	Rural Pop.	Total Pop.	Urban Pop.	Rural Pop.	Total Pop.
Adams		4,594	6,777		4,086	6,346
Camp Point	1,150			1,260		
Clayton	1,033			1,000		
Benton, Ind		2,381	2,381			
Brown		5,652	11,951		5,256	11,557
Mt. Sterling	1,655			1,960		
Bureau		19,661	26,894		20,223	31,784
Ladd				1,324		
Princeton	3,396			4,023		
Spring Valley	3,837			6,214		
Calhoun		3,369	3,369		3,685	3,685
Cass		9,080	15,953		9,594	17,222
Ashland	1,045			1,201		
Beardstown	4,226			4,827		
Virginia City	1,602			1,600		
Champaign		7,222	7,222		7,345	7,345

Population for 1890 and 1900—Continued.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Christian		20,743	30,531		20,239	32,790
Assumption	1,076			1,702		
Edinburg		806		1,071		
Pana	5,077			5,530		
Taylorville	2,829			4,248		
*Cook	20,048	32,737	52,785	32,327	34,136	66,463
De Kalb		9,716	9,716		7,375	7,375
De Witt		13,050	17,011		12,856	18,972
Clinton	2,594			4,452		
Farmer City	1,367			1,664		
Du Page		13,067	22,551		14,936	28,196
Downer's Grove				2,103		
Elmhurst	1,050			1,728		
Hinsdale	1,584			2,578		
Naperville	2,216			2,629		
West Chicago	1,506			1,877		
Wheaton	1,622			2,345		
Ford		8,963	10,766		8,264	10,318
Gibson City	1,803			2,054		
Fulton		30,336	43,110		31,327	46,201
Astoria	1,357			1,684		
Canton	5,604			6,564		
Cuba	1,114			1,198		
Farmington	1,375			1,729		
Lewistown	2,166			2,504		
Vermont	1,158			1,195		
Green		16,081	23,791		15,581	23,402
Carrolton	2,258			2,355		
Greenfield	1,131			1,085		
Roodhouse	2,360			2,351		
Whitehall	1,961			2,030		
Grundy		12,455	21,024		13,299	24,136
Braceville	2,150			1,669		
Carbon Hill				1,252		
Coal City	1,672			2,607		
Gardner	1,094			1,036		
Morris	3,653			4,273		
Hancock		10,203	14,047		9,868	14,712
Augusta	1,077			1,149		
Carthage	1,654			2,104		
La Harpe	1,113			1,591		
Iroquois		29,123	34,252		29,810	37,206
Gilman	1,112			1,441		
Milford	1,000			1,077		
Onarga	1,000			1,270		
Sheldon				1,103		
Watseka	2,017			2,505		
Jasper, Ind		9,730	11,185			
Rensselaer	1,455					
Jersey		8,776	11,983		8,629	12,146
Jerseyville	3,207			3,517		
Kane		14,457	60,916		16,341	74,491
Aurora	19,688			24,147		
Batavia	3,543			3,871		
Dundee	2,023			2,765		
Elgin	17,823			22,246		
Geneva	1,692			2,446		
St. Charles	1,690			2,675		

* Cook county drainage to Illinois tributaries, but exclusive of Chicago.

Population for 1890 and 1900—Continued.

County—City.	1890.			1900.		
	Urban Pop.	Rural Pop.	Total Pop.	Urban Pop.	Rural Pop.	Total Pop.
Kankakee		18,072	28,732		19,015	37,154
Bradley				1,518		
Kankakee	9,025			13,595		
Momence	1,635			2,026		
St. Anne				1,000		
Kendall		10,281	12,106		9,833	11,467
Plano	1,825			1,634		
Kenosha, Wis		6,050	6,050			
Knox		16,570	27,251		17,031	30,214
Abingdon	1,321			2,022		
Knoxville	1,728			1,857		
Pt. Galesburg	7,632			9,304		
Kosciusko, Ind		4,774	4,774			
Lake		11,737	11,737		12,788	12,788
Lake, Ind		7,600	7,600			
La Porte, Ind		11,545	18,671			
La Porte	7,126					
LaSalle		34,897	80,798		35,193	87,776
Crotty	1,190			1,036		
Earlville	1,058			1,122		
Kangley				1,004		
LaSalle	9,855			10,446		
Marseilles	2,210			2,559		
Mendota	3,545			3,736		
Ottawa	9,985			10,588		
Peru	5,550			6,863		
Streator	11,414			14,079		
Utica	1,094			1,150		
Lee		3,961	3,961		4,225	4,225
Livingston		30,972	38,455		30,577	42,035
Chatsworth				1,038		
Dwight	1,354			2,015		
Fairbury	2,324			2,187		
Forrest	1,021				952	
Odell				1,000		
Pontiac	2,784			4,266		
Logan		16,229	25,489		17,005	28,680
Atlanta	1,178			1,270		
Lincoln	6,725			8,962		
Mt. Pulaski	1,357			1,643		
Macon		20,078	36,083		22,006	44,003
Decatur	16,841			20,784		
Maroa	1,164			1,213		
Macoupin		21,176	27,603		18,761	27,582
Carlinville	3,293			3,502		
Girard	1,524			1,661		
Nilwood				1,378		
Virden	1,610			2,280		
Marshall, Ill		9,439	13,653		9,017	16,370
Henry	1,512			1,637		
Lacon	1,649			1,601		
Toluca				2,629		
Wenona	1,053			1,486		
Marshall, Ind		14,755	19,618			
Bourbon	1,064					
Bremen	1,076					
Plymouth	2,723					

Population for 1890 and 1900—Continued.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Mason		11,673	16,067		12,383	17,491
Havana	2,525			3,268		
Mason City	1,869			1,890		
McDonough		19,458	27,467		18,912	28,412
Bushnell	2,314			2,490		
Colchester	1,643			1,635		
Macomb	4,052			5,375		
McHenry		10,096	11,075		11,375	12,388
McHenry		979		1,013		
McLean		35,422	63,036		35,053	67,790
Bloomington	20,487			23,286		
Chenoa	1,226			1,512		
Colfax				1,153		
LeRoy	1,258			1,629		
Lexington	1,187			1,415		
Normal	3,459			3,795		
Menard		8,728	13,120		8,975	14,336
Athens		944		1,535		
Greenview	1,106			1,019		
Petersburg	2,342			2,807		
Montgomery			2,962			3,424
Morgan		18,364	32,636		18,355	35,006
Jacksonville	12,935			15,078		
Waverly	1,337			1,573		
Newton, Ind		8,803	8,803			
Peoria		25,078	70,378		25,296	88,608
Averyville				1,573		
Chillicothe	1,632			1,699		
Elmwood	1,548			1,582		
Peoria	42,120			58,458		
Piatt		6,956	10,663		6,600	11,073
Bement	1,125			1,484		
Cerro Gordo		939		1,008		
Monticello	1,643			1,982		
Pike		8,576	9,976		8,719	10,123
Griggsville	1,400			1,404		
Porter, Ind		6,481	6,481			
Putnam		4,730	4,730		4,746	4,746
Racine, Wis		5,595	7,637			
Burlington	2,042					
Sangamon		32,224	61,195		33,473	71,593
Auburn		874		1,281		
Ridgely	1,007			1,169		
Riverton	1,127			1,511		
Springfield	24,963			34,159		
Schuyler		13,982	16,013		13,837	16,129
Rushville	2,031			2,292		
Scott		8,762	10,304		8,744	10,455
Winchester	1,542			1,711		
Shelby		2,551	3,399		3,072	4,550
Moweaqua		848		1,478		
Stark, Ill		7,921	9,982		7,859	10,186
Toulon		945		1,050		
Wyoming	1,116			1,277		
Stark, Ind		7,339	7,339			

Podutation for 1890 and 1900—Continued.

County—City.	1890.			1900.		
	Urban Pop.	Rural Pop.	Total Pop.	Urban Pop.	Rural Pop.	Total Pop.
St. Joseph, Ind		10,319	10,319			
Tazewell		20,636	29,550		22,038	33,221
Delavan	1,176			1,304		
Pekin	6,437			8,420		
Washington	1,301			1,459		
Walworth, Wis		13,240	21,934			
Delavan	2,038					
Geneva	2,297					
White Water	4,359					
Warren		5,273	6,061		5,293	6,307
Roseville		788		1,014		
Waukesha, Wis		12,097	21,185			
Waukesha	6,359					
Oconomowoc	2,729					
Will		26,363		59,010	33,595	71,309
Braidwood	4,641			3,279		
Joliet	23,264			29,353		
Lockport	2,449			2,659		
Peotone		717		1,003		
Wilmington	1,576			1,420		
Woodford		16,279	21,429		16,175	21,822
El Paso	1,353			1,441		
Eureka	1,481			1,661		
Minonk	2,316			2,545		

Population in the Drainage Basins of Streams Tributary to the Illinois River.

Des Plaines River.

County—City.	1890.			1900.		
	Urban Pop.	Rural Pop.	Total Pop.	Urban Pop.	Rural Pop.	Total Pop.
*Cook	20,048	28,757	48,805	32,327	29,803	62,130
DuPage		5,837	9,431		6,283	12,692
Downers Grove		960		2,103		
Elmhurst	1,050			1,728		
Hinsdale	1,584			2,578		
Kenosha, Wis		1,800	1,800		*1,800*	*1,800*
Lake		7,641	7,641		8,399	8,399
Will		7,506	33,219		7,822	39,834
Joliet	23,264			29,353		
Lockport	2,449			2,659		
Total	49,355	51,541	100,896	70,748	54,107	124,855

* Cook county draining to Illinois tributaries, but exclusive of Chicago.

Population for 1890 and 1900—Continued.

DuPage River.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Cook		737	737		862	862
DuPage		7,776	13,120		8,653	15,504
Naperville	2,216			2,629		
West Chicago	1,506			1,877		
Wheaton	1,622			2,345		
Will		5,465	5,465		5,338	5,338
Total	5,344	13,978	19,322	6,851	14,853	21,704

Kankakee River.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Benton, Ind		2,381	2,381		*2,381*	*2,381*
Iroquois		29,123	34,252		29,810	37,206
Gilman	1,112			1,441		
Milford	1,000			1,077		
Onarga	1,000			1,270		
Sheldon				1,103		
Watseka	2,017			2,505		
Jasper, Ind		9,730	11,185		*9,730*	*11,185*
Rensselaer	1,455			*1,455*		
Kankakee		12,589	23,967		13,573	31,712
Bradley				1,518		
Kankakee	9,025			13,595		
Momence	1,635			2,026		
St. Anne		718		1,000		
Kosciusko, Ind		4,774	4,774		*4,774*	*4,774*
Lake, Ind		7,600	7,600		*7,600*	*7,600*
LaPorte, Ind		11,545	18,671		*11,545*	*18,671*
LaPorte	7,126			*7,126*		
Marshall, Ind		14,755	19,618		*14,755*	*19,618*
Bourbon	1,064			*1,064*		
Bremen	1,076			*1,076*		
Plymouth	2,723			*2,723*		
Newton, Ind		8,803	8,803		*8,803*	*8,803*
Porter, Ind		6,481	6,481		*6,481*	*6,481*
Stark, Ind		7,339	7,339		*7,339*	*7,339*
St. Joseph, Ind		10,319	10,319		*10,319*	*10,319*
Will		13,392	20,326		20,435	26,137
Braidwood	4,641			3,279		
Peotone		717		1,003		
Wilmington	1,576			1,420		
Total	35,450	143,263	178,713	44,681	147,545	192,226

Population for 1890 and 1900.—Continued.

Fox River.

County. City.	1890.			1900.		
	Urban Pop.	Rural Pop.	Total Pop.	Urban Pop.	Rural Pop.	Total Pop.
*Cook		3,243	3,243		3,471	3,471
DeKalb		9,716	9,716		7,375	7,375
Kane		14,457	60,916		16,341	74,491
Aurora	19,688			24,147		
Batavia	3,543			3,871		
Dundee	2,023			2,765		
Elgin	17,823			22,246		
Geneva	1,692			2,446		
St. Charles	1,690			2,675		
Kendall		4,683	6,508		3,790	5,424
Plano	1,825			1,634		
Kenosha, Wis		6,050	6,050		*6,050*	*6,050*
Lake, Ill		4,096	4,096		4,389	4,389
LaSalle		9,310	10,368		9,887	11,009
Earlville	1,058			1,122		
McHenry		10,096	11,075		11,375	12,388
McHenry		979		1,013		
Racine, Wis		5,595	7,637		*5,595*	*7,637*
Burlington	2,042			*2,042*		
Walsworth, Wis		13,240	21,934		*13,240*	*21,934*
Delavan	2,038			*2,038*		
Geneva	2,297			*2,297*		
Whitewater	4,359			*4,359*		
Waukesha, Wis		12,097	21,185		*12,098*	*21,185*
Oconomowoc	2,729			*2,729*		
Waukesha	6,359			*6,359*		
Total	69,166	93,562	162,728	81,743	93,610	175,353

Vermilion River.

County. City.	1890.			1900.		
	Urban Pop.	Rural Pop.	Total Pop.	Urban Pop.	Rural Pop.	Total Pop.
Ford		3,782	3,782		3,773	3,773
La Salle		9,934	22,332		9,850	24,933
Kangley		934		1,004		
Streator	11,414			14,079		
Livingston		23,672	31,428		24,308	33,751
Chatsworth		827		1,038		
Fairbury	2,324			2,187		
Forrest	1,021				952	
Odell		800		1,000		
Pontiac	2,784			4,266		
McLean		1,146	2,372		1,037	2,549
Chenoa	1,226			1,512		
Woodford		1,082	3,398		1,050	3,595
Minonk	2,316			2,545		
Total	21,085	42,227	63,312	27,631	40,970	68,601

Population for 1890 and 1900.—Continued.

Mackinaw River.

County. City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
McLean		14,012	18,658		15,456	21,819
Colfax				1,158		
Normal	3,459			3,795		
Lexington	1,187			1,415		
Tazewell		12,467	13,768		12,051	13,510
Washington	1,301			1,459		
Woodford		8,928	11,762		8,865	11,967
El Paso	1,353			1,441		
Eureka	1,481			1,661		
Total	8,781	35,407	44,188	10,924	36,372	47,296

Spoon River.

County. City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Bureau		1,814	1,814		1,839	1,839
Fulton		18,099	28,358		19,446	31,441
Canton	5,604			6,564		
Cuba	1,114			1,198		
Farmington	1,375			1,729		
Lewiston	2,166			2,504		
Knox		16,570	27,251		17,031	30,214
Abingdon	1,321			2,022		
Pt. Galesburg	7,632			9,304		
Knoxville	1,728			1,857		
Peoria		1,912	1,912		1,795	1,795
Stark		7,921	9,982		7,859	10,186
Toulon		945		1,050		
Wyoming	1,116			1,277		
Warren		5,273	6,061		5,293	6,307
Roseville		788		1,014		
Total	22,056	53,322	75,378	28,519	53,263	81,782

Sangamon River.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Cass		4,350	6,997		4,270	7,071
Ashland	1,045			1,201		
Virginia City	1,602			1,600		
Champaign		7,222	7,222		7,345	7,345
Christian		20,743	30,531		20,239	32,790
Assumption	1,076			1,702		
Edinburg		806		1,071		
Pana	5,077			5,530		
Taylorville	2,829			4,248		
DeWitt		13,050	17,011		12,856	18,972
Clinton	2,594			4,452		
Farmer City	1,367			1,664		
Ford		5,181	6,984		4,491	6.545
Gibson City	1,803			2,054		
Logan		16,229	25,489		16,805	28,680
Atlanta	1,178			1,270		
Lincoln	6,725			8,962		
Mt. Pulaski	1,357			1,643		
Macon		20,078	38,083		22,006	44,003
Decatur	16,841			20,784		
Maroa	1,164			1,213		
Mason		5,637	7,506		6,200	8,090
Mason City	1,869			1,890		
McLean		20,261	42,006		18,507	43,422
Bloomington	20,487			23,286		
LeRoy	1,258			1,629		
Menard		8,728	13,120		8,975	14,336
Athens		944		1,535		
Greenview	1,106			1,019		
Petersburg	2,342			2,807		
Montgomery		2,034	2,034		2,127	2,127
Piatt		6,956	10,663		6,599	11,073
Bement	1,125			1,484		
Cerro Gordo		939		1,008		
Monticello	1,643			1,982		
Sangamon		33,224	61,195		33,473	71,593
Auburn		874		1,281		
Ridgely	1,007			1,169		
Riverton	1,127			1,511		
Springfield	24,963			34,159		
Shelby		2,551	3,399		3,072	4,550
Moweaqua		848		1,478		
Tazewell		2,450	2,450		2,499	2,499
Total	101,585	173,105	274,690	133,632	169,464	303,096

Population for 1890 and 1900—Continued.

Crooked Creek.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Adams	....	1,708	1,708	....	1,717	1,717
Brown	....	3,201	3,201	....	3,026	3,026
Hancock	....	10,203	14,047	....	9,868	14,712
Augusta	1,077	....	....	1,149	....	....
Carthage	1,654	....	....	2,104	....	....
La Harpe	1,113	....	....	1,591	....	....
McDonough	....	19,016	27,025	....	18,472	27,972
Bushnell	2,314	....	....	2,490	....	....
Colchester	1,643	....	....	1,635	....	....
Macomb	4,052	....	....	5,375	....	....
Schuyler	....	9,422	9,422	....	7,147	7,147
Total	11,853	43,550	55,403	14,344	40,230	54,574

Macoupin Creek.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Green	....	7,087	10,476	....	6,630	10,070
Carrollton	2,258	....	....	2,355	....	....
Greenfield	1,131	....	....	1,085	....	....
Jersey	....	4,208	7,415	....	4,724	8,241
Jerseyville	3,207	....	....	3,517	....	....
acoupin	....	20,312	26,739	....	17,933	26,754
Carlinville	3,293	....	....	3,502	....	....
Girard	1,524	....	....	1,661	....	....
Nilwood	....	....	....	1,378	....	....
Virden	1,610	....	....	2,280	....	....
Montgomery	....	928	928	....	1,297	1,297
Total	13,023	32,535	45,558	15,778	30,584	46,362

McKee's Creek.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Adams	....	2,886	5,069	....	2,369	4,629
Camp Point	1,150	....	....	1,260	....	....
Clayton	1,033	....	....	1,000	....	....
Brown	....	5,377	7,032	....	5,047	7,007
Mt. Sterling	1,655	....	....	1,960	....	....
Pike	....	3,680	5,080	....	3,421	4,825
Griggsville	1,400	....	....	1,404	....	....
Total	5,238	11,943	17,181	5,624	10,837	16,461

Population Directly Tributary to the Illinois River, not Included in Statement of Tributary Streams.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Brown		1,718	1,718		1,524	1,524
Bureau		17,847	25,080		18,384	29,945
Ladd				1,324		
Princeton	3,396			4,023		
Spring Valley	3,837			6,214		
Calhoun		3,369	3,369		3,685	3,685
Cass		4,730	8,956		5,324	10,151
Beardstown	4,226			4,827		
Fulton		12,237	14,752		11,881	14,760
Astoria	1,357			1,684		
Vermont	1,158			1,195		
Greene		8,994	13,315		8,951	13,332
Roodhouse	2,360			2,351		
Whitehall	1,961			2,030		
Grundy		12,455	21,024		13,299	24,136
Braceville	2,150			1,669		
Carbon Hill				1,252		
Coal City	1,672			2,607		
Gardner	1,094			1,036		
Morris	3,653			4,273		
Jersey		4,568	4,568		3,905	3,905
Kankakee		4,765	4,765		5,442	5,442
Kendall		5,598	5,598		6,043	6,043
LaSalle		14,669	48,096		15,456	51,834
Crotty	1,190			1,036		
LaSalle	9,855			10,446		
Marseilles	2,210			2,559		
Mendota	3,545			3,736		
Ottawa	9,985			10,588		
Peru	5,550			6,863		
Utica	1,094			1,150		
Lee		3,961	3,961		4,225	4,225
Livingston		5,673	7,027		6,269	8,284
Dwight	1,354			2,015		
Macoupin		864	864		828	828
McDonough		442	442		440	440
Marshall		9,439	13,653		9,017	16,370
Henry	1,512			1,637		
Lacon	1,649			1,601		
Toluca				2,629		
Wenona	1,053			1,486		
Mason		6,036	8,561		6,133	9,401
Havana	2,525			3,268		
Morgan		18,364	32,636		18,355	35,006
Jacksonville	12,935			15,078		
Waverly	1,337			1,573		
Peoria		23,176	68,466		23,501	86,813
Averyville				1,573		
Chillicothe	1,632			1,699		
Elmwood	1,548			1,582		
Peoria	42,110			58,458		
Pike		4,896	4,896		5,298	5,298
Putnam		4,730	4,730		4,746	4,746

Population Directly Tributary to the Illinois River—Concluded.

County—City.	1890. Urban Pop.	1890. Rural Pop.	1890. Total Pop.	1900. Urban Pop.	1900. Rural Pop.	1900. Total Pop.
Schuyler		4,560	6,591		6,690	8,982
Rushville	2,031			2,292		
Scott		8,762	10,304		8,744	10,455
Winchester	1,542			1,711		
Tazewell		5,719	13,332		7,488	17,212
Delavan	1,176			1,304		
Pekin	6,437			8,420		
Woodford		6,269	6,269		6,260	6,260
Total	139,134	193,841	332,975	177,189	201,888	379,077

STREAM GAUGINGS.

Gaugings of the principal tributaries and of the Illinois river at Peoria were made during the low water stage in October, 1899, and represent approximately the average conditions of these streams during the late summer and early fall months. These gaugings were taken with a Price's current meter which had been previously rated by the United States Geological Survey. The beds of the streams were accurately cross sectioned and readings taken at the following stations:

Des Plaines River—At wagon bridge about 1 mile below C., B. & Q. R. R. bridge, near Riverside. Cross section was also taken at C., B. & Q. R. R. bridge for gaugings at higher stages of the river.

Flow 13.21 cu. ft. per sec.

Turbidity .04.

DuPage River—At wagon bridge about 5 miles above the Illinois & Michigan crossing, and about one-half mile below the C., B. & Q. R. R. bridge, which point is above the influence of slack water of the canal dam.

Flow 32.77 cu. ft. per sec.

Turbidity—Clear.

Kankakee River—At C. & A. R. R. bridge near Lorenzo, Ill. Rain for three days prior to gaugings and the river 2 or 3 inches higher than previous to rains, but still quite low.

Flow 509.24 cu. ft. per sec.

Turbidity .032.

Fox River—At wagon bridge at Weldon about 8 miles above its mouth.

Flow 321.95 cu. ft. per sec.

Turbidity .019.

Vermilion River—Above Streator water work's dam and impounding reservoir.

Flow 0.9 cu. ft. per sec., which is less than the amount of water pumped daily from the impounding river to supply the city of Streator with water. A cross section of the stream was taken at the C. & A. R. R. bridge at Streator for gauging at higher stage of the river. About 200 ft. above this bridge, above which point the river receives practically all of the sewage of the city, a gauging showed approximately a flow of 4 cu. ft. per sec., which is the better figure to take in computing its contribution to the Illinois river.

Turbidity above the city .18.

Spoon River—At the C., B. & Q. R. R. bridge near Lewiston.

Flow 81.76 cu. ft. per sec.

Turbidity .09.

Sangamon River—At wagon bridge one-half mile below the C., P. & St. L. R. R. bridge near Chandlerville. Cross section taken at openings in railroad for high water gaugings.

Flow, 372.30 cu. ft. per sec.

Turbidity, .08.

Discharge of Illinois River at Peoria, Illinois.

(Computed from Current Meter Observations and Cross Sections.)

Date.	Stage of River.		Discharge.	Velocity.
	P. & P. U. Ry. Bridge.	Bridge St. Bridge.	Cu. ft. second.	Ft. per second.
Oct. 19, 1899	4′ 8″	4.3	2,136	....
Mar. 13, 1900	15′11″	15.4	33,797	2.432
Mar. 15, 1900	19′ 3″	19.2	51,086	3.001
Mar. 29, 1900	15′ 8″	16.0	30,483	....
May 23, 1900	8′11″	8.8	9,296	1.153
June 27, 1900	7′ 4″	7.2	6,600	1.041
Aug. 29, 1900	7′ 9″	7.7	6,817	1.021
Sept. 27, 1900	5′10″	5.8	4,558	0.890

NOTE.—The observation of March 29, 1900, is not accurate on account of drift material and has been disregarded in preparing the curve of discharge.

The turbidity tests were made in accordance with that adopted by the Massachusetts State Board of Health. This is an arbitrary scale of the reciprocal of the depth in inches at which a small platinum wire can be seen when immersed in the water.

VELOCITY OF ILLINOIS RIVER AT PEORIA, ILL.

The total fall in the Illinois river throughout the lower 225 miles of its course is thirty feet, or an average of 0.132 feet per mile. This fall is very small and the current very sluggish. In some of the lakes, or wide reaches as at Peoria, the current is almost imperceptible. There are short reaches of narrow channel, where the fall is considerably more than the average.

The discharge guagings of the Illinois given above, were taken at the P. & P. U. Railroad bridge, 8,504 feet below the mouth of Peoria Lake where the river is crossed by the Bridge street bridge. The U. S. Weather Bureau maintains a guage at the Bridge street bridge,

and an observer reports daily the stage of the river. At the P. & P. U. Railroad bridge a guage board is maintained, but the stage of the river is not taken. These two guages are set with their zeros at low water mark for their respective locations prior to the construction of the Coperas Creek dam, which was constructed to improve navigation, and raised the low water stage of the river at Peoria from three to four feet. The zero of the guage at the P. & P. U. Railroad bridge is 45-hundredths of a foot below the level plane of the guage at the Bridge street bridge. Observations show that the slope of the surface of the water in the Illinois river ranges from .33 feet to one foot below these two points, equal to .204 feet to .62 feet per mile. The average slope for stages ranging from five to eight feet has been taken as .4 feet, equal to .248 feet per mile; hence the sine of the slope is .000047036. For the higher stages no definite conclusion has been reached regarding the slope of the surface, as it is more affected by winds and the stage of the Mississippi river, as well as by the progress of the flood period.

Using the sine of slope given above, the velocity, as determined by the current meter, the cross-section and the wetted perimeter, as determined by surveys in the Ganguillet and Kutter formula for the velocity of flow in streams, and solving for "n," the "co-efficient of roughness," it is found to be .0414. This factor is one which is of much importance in estimating the velocity of streams when the current can not be directly measured. For large streams sufficient data is not at hand for the accurate estimation of the flow; therefore, all such data is of considerable importance to hydraulic works. With a view to extensive distributing of such data, the following table from the recently issued report of the "Special Commission Chicago Drainage Channel" is given, with the deductions for the Illinois river added.

TABLE OF HYDRAULIC ELEMENTS AMD DEDUCTIONS FROM GAUGINGS OF VARIOUS CHANNELS.

(For use in the Ganguillet and Kutter formula.)

$$V=\frac{a+\frac{l}{n}+\frac{m}{S}}{1+(a+\frac{m}{S})\ \frac{n}{\sqrt{R}}}\sqrt{RS}=C\sqrt{RS}$$

V=Mean velocity.
R=Mean hydraulic radius.

S=Sine of slope.
n=Coefficient of roughness.

a=41.66.
l=1.811.
m=.00281.

Description of Channel, Authority, Etc.	R.	C.	S.	n.	V.
Artificial channel of the DesPlaines river opposite Gary, Ill. Straight and fairly level across. About 200 feet wide on bottom.—From Jour. West. Soc. C. E., 1896....	7.82 7.20	79.92 72.70	.0000796 .0000707	.029 .029	....
Irwadi river at Saiktha, Burmah.—Quoted by Kutter from Gorden, 1873	21.13 22.97	105.90 103.60	.0000344 .0000387	.029 .029	2.857 3.091
Solani embankment, 15th mile, new site, earth channel, side slopes 1¼ to 1.—Quoted by Kutter from Cunningham, Roorkee, 1880..........	8,35	92.80	.0002200	.023	3.980
Same, old site, side slopes 2½ to 1	8.64	89.10	.0002310	.024	3.980
Linth canal at Grynau. Trapezoidal earth channel.—From Kutter..........	9.18	94.90	.0003700	.022	5.530
Seine at Poissy.—Quoted by Kutter..........	17.87	91.10	.0000750	.029	3.330
Rhine at Germersheim. Gravel and fine detritus.—Quoted by Kutter from Grebnau, 1867..........	17.27	78.70	.0003490	.030	6.101
Rhine at Byland. Reach over 11 miles.—Quoted by Kutter from Krayenhoff, 1812	16.45	89.20	.0000977	.029	3.575
Bayou Plaquemine.—Quoted by Kutter from C. Ellet, 1851	18.35	84.50	.0002064	.030	5.198
Same	15.32	84.40	.0001437	.029	3.959
Sacremento River at Freeport, Cal.—From the report of the commissioner of public works of California for 1894. Measurements made with current meter in 1879.	23.45 23.99 23.92 23.54 19.93	95.62 95.73 98.90 79.05 84.68	.0000744 .0000786 .0000675 .0000778 .0000580	.029 .029 .029 .037 .034	3.994 4.157 3.974 3.383 2.879
Northren canal, Lowell, Mass. Dry stone walls.—Hiram F. Mills, 1899	12.96 13.35 13.30	122.63 104.26 100.31	.0000209 .0000417 .0000642	.022 .025 .025	2.020 2.460 2.931
Illinois and Michigan canal. Trapezoidal earth channel.—Desmond FitzGerald, 1899..........	6.13	97.30	.0000249	.023	1.204

Hydraulic Elements and Deductions.—Concluded.

Description of Channel, Authority, Etc.	R.	C.	S.	n.	V.
Mississippi river.—From report of Mississippi River Commission, 1882; measurements in 1881:					
At Clayton, Ia., August 22	13.74	85.79	.0000250	.034	1.590
" " 29	14.32	85.55	.0000280	.034	1.713
" June 14	19.85	82.37	.0000688	.034	3.044
At Hannibal, Mo., August 16	16.50	104.12	.0000240	.029	2.072
" September 9	16.47	111.29	.0000260	.026	2.305
" " 13	17.50	77.25	.0000730	.036	2.761
At St. Louis, Mo., January 12	14.57	55.04	.0001294	.049	2.390
" " 14	14.17	53.87	.0001231	.050	2.250
" " 25	13.49	64.10	.0000971	.041	2.320
" " 31	13.16	70.75	.0000889	.036	2.420
" February 2	13.21	81.11	.0000702	.031	2.470
" May 27, slough	8.40	57.21	.0001811	.040	2.230
" June 6, slough	5.69	57.44	.0000767	.037	1.200
Illinois river at Peoria, Ill. Fine detritus banks and gravely bottom; channel dredged and barges dumped at one side, but within the cross-section; stream about 700 feet, average width.—Jacob A. Harman, 1900.	8.00	58.50	.0000470	.041	1.136

The velocity given above is for average cross-section for about three-quarters of a mile above the P. & P. U. railroad bridge, where the current readings were taken. In the preceding table of discharges from actual observations, the average velocities at the bridge are given, the range is from .89 feet per second to 3.001 feet per second—or .607 miles to 2.042 miles per hour.

Additional gaugings are necessary to arrive at an absolutely correct rate of discharge for the flood periods, but the data at hand is sufficient to warrant the general deductions and conclusions brought out in this report.

RAINFALL TABLES.

The monthly and annual rain-fall as taken by U. S. Weather Bureau observers has been compiled and averaged for the ten years, 1890 to 1899 inclusive. The stations have been arranged according to the sub-basin on which they are located or were near, so that the average monthly and annual rain-fall for each river basin tributary to the Illinois has been determined. These data show that the annual rainfall for the 10 years was 31.82 inches on the Des Plaines and 37.37 inches on McKee's creek, the most northern and most southern streams respectively, a difference of about five inches or 16 per cent in favor of the southern streams. The average annual rain-fall for the ten years was 34 36 inches, being 3.49 inches below the normal for the State as shown in a late table by Leverett in water resources of Illinois:

Monthly Precipitation on Various Drainage Basins of the Illinois River.

DES PLAINES RIVER.

County.	City.	January...	February..	March......	April......	May......	June......	July......	August....	September.	October....	November..	December..	Annual ...
1890.														
Cook	*Chicago	2.98	2.42	2.10	3.23	5.13	3.25	2.57	2.58	1.39	4.20	1.59	1.25	32.69
Lake..........	*Ft. Sheridan.......	2.68	1.84	2.33	4 82	5.25	7.77	1.25	2.47	1.32	6.02	0.92	2.27	38.94
"	*Lake Forrest	2.76	1.77	3.29	4.29	5.08	5.29	....	....	....	....	....	....	......
	Averages........	2.83	2.13	2.22	4.03	5.19	5,51	1.91	2.53	1.36	5.11	1.26	1.76	35.82
1891.														
Lake..........	*Ft. Sheridan.......	1.73	2.25	2.56	4.33	2.25	5.69	1.94	3.75	0.48	1.55	4.09	0.90	31.52
Cook..........	*Chicago	1.99	1.95	2.13	3.14	2.09	2.42	2.47	4.52	0.32	0.36	3.83	1.32	26.54
	Averages........	1.86	2.10	2.34	3.73	2.17	4.06	2.21	4.14	0.40	0.96	3.96	1.11	29.03
1892.														
Cook..........	*La Grange.	*1,23*	0.83	2.20	2.76	8.00	12.25	*2.39*	*1.36*	1.70	0.81	2.24	1.93	*37.70*
"	*Chicago	1.99	1.57	2.21	2.17	6.77	10.58	2.23	1.85	1.34	1.54	2 68	1.63	36.56
Lake..........	*Ft. Sheridan.......	0.48	1.81	0.95	3.57	6.51	10.91	2.54	0.86	1.67	0.00	1.78	2.60	33.68
	Averages........	1.23	1.40	1.79	2.83	7.09	11.25	2.39	1.36	1.57	0.78	2.23	2.05	35.98

* See end of table—page 159.

Rainfall Tables—Continued.

County.	City.	January...	February...	March.	April.......	May.........	June.	July	August	September.	October....	November.	December .	Annual ....
1893.														
Cook..	*La Grange.	1.91	1.79	2.15	5.61	2.27	5.30	2.96	0.23	2.84	0.52	2.26	2.00	29.84
"	*Chicago	2.08	2.44	1.69	4.16	1.93	3.59	3.08	0.18	1.98	1.75	2.45	2.14	27.47
Lake..........	*Ft. Sheridan.......	2.02	1.10	1.95	5.87	2.07	3.62	3.77	0.10	3.62	1.19	2.87	1.61	29.79
	Averages........	2.00	1.78	1.93	5.21	2.09	4.17	3.27	0.17	2.81	1.15	2.53	1.92	29.03
1894.														
Will.	Braidwood..	1.16	1.31	2.87	2.23	3.69	2.84	0.46	0.85	5.99	1.18	1.68	1.00	25.26
Cook.	*La Grange.	1.64	1.72	*2.51*	*3.23*	3.16	2.09	*1.45*	*0.75*	8.87	1.04	1.45	0.71	27.62
"	*Chicago	1.55	2.13	2.66	2.65	3.35	1.96	0.60	0.60	8.28	0.84	1.18	1.66	27.46
Lake..........	*Ft. Sheridan.......	2.94	1.45	2.01	4.70	4.01	0.51	T...	0.27	6.56	2.49	1.64	1.26	27.84
McHenry.	*Chemung	*1.82*	*1.65*	*2.51*	3.34	3.02	3.56	0.76	1.28	8.33	1.87	2.27	0.60	31.01
	Averages........	1.82	1.65	2.51	3.23	3.45	2.19	0.45	0.75	7.61	1.48	1 65	1.05	27.85
1895.														
Will.	Joliet..	*1.94*	*0.78*	*1.17*	*1.89*	1.95	1.26	4.32	2.96	0.93	0.67	2.90	6.62	27.29
"	Braidwood..	1.82	0.67	1.04	1.92	....	......	....	....	....	....	....	....	......
Cook	*La Grange.	1.64	0.45	0.85	1.17	2.24	2.00	*3.24*	5.69	1.10	0.77	5.09	6.04	30.28
"	Chicago.	2.15	1.60	1.32	0.86	1.99	1.79	2.42	6.49	0.89	0.51	5.60	6.76	32.38
Lake	*Ft. Sheridan.......	2.61	0.32	0.45	2.50	3.70	2.60	3.30	3.81	4.88	0.41	2.14	5.50	32.22
McHenry.	*Chemung	1.47	0.95	2.18	2.52	4.96	2.11	2.91	3.06	4.74	0.66	2.10	2.59	30.25
	Averages........	1.95	0.82	1.19	1.77	2.97	1.95	3.24	4.40	2.51	0.60	3.57	5.50	30.48
1896.														
Will.	Joliet..	1.14	2,07	1.15	2.82	5.28	3.89	4.97	2.75	6.69	0.86	2.96	0.36	34.94
Cook	*La Grange.	1.16	2.39	1.04	4.21	4.73	2.63	*4.39*	*2.58*	5.39	0.85	3.03	0.10	32.50
"	Chicago.	1.12	3.48	1.26	2.79	4.16	2.82	3.61	3.52	6.70	1.36	2.16	0.16	33.14
Lake..	*Ft. Sheridan.......	0.56	1.06	2.53	3.13	2.35	1.95	3.86	1.79	5.60	0.97	2.80	0.65	27.25
McHenry	*Chemung	0.99	1.93	3.48	6.78	4.18	3.18	5.10	2.27	8.56	1.06	2.58	0.77	40.88
	Averages........	0.99	2.19	1.89	3.95	4.14	2.89	4.39	2.58	6.59	1.02	2.71	0.41	33.74
1897.														
Will.	*Joliet.	6.67	1.84	3.80	2.87	1.25	5.19	1.59	0.55	0.63	0.44	4.42	1.68	30.93
Cook	*La Grange.	6.09	1.83	4.00	3.50	1.85	3.74	2.97	1.57	0.80	0.33	3.82	1.36	31.86
"	Chicago.	4.63	2.22	3.56	2.23	0.84	3.60	1.47	1.70	0.84	0.18	3.06	1.62	25.95
Lake	*Ft. Sheridan.......	4.41	1.07	4 16	2.20	1.32	4.41	1.34	1.52	1.10	0.25	3.53	1.51	26.82
McHenry.	*Chemung	5.06	1.77	5.25	4.66	1.67	6.36	4.73	2.00	1.18	0.84	2.37	1.40	37.29
	Averages........	5.37	1.75	4.15	3.09	1.39	4.66	2.42	1.47	0.91	0.41	3.44	1.51	30.57
1898.														
Will.	*Joliet.	4.05	2.28	6.12	1.42	3.82	7.89	1.59	4.69	3.20	4.53	2.61	2.15	44.35
Cook	*La Grange.	4.30	2.60	5.87	1.14	3.50	6.92	2.77	4.59	3.97	4.21	2.69	1.56	44.12
"	Chicago.	3.54	2.59	4.60	0.76	2.23	5.30	1.94	3.03	3.16	3.26	2.25	1.11	33.77
Lake	*Ft. Sheridan.......	2.59	2.91	3.13	1.35	2.43	2.56	1.65	2.86	2.48	3.10	1.44	0.91	27.41
McHenry.	*Chemung	2.89	2.73	4.25	2.20	3.71	5.97	2.54	5.66	2.72	3.41	2.09	0.89	39.06
	Averages........	3.47	2.62	4.79	1.37	3.14	5.73	2.10	4.17	3.11	3.70	2.22	1.32	37.74
1899.														
Will.	*Joliet.	0.82	1.68	2.23	0.35	4.69	2.17	5.26	1.74	2.44	2.39	1.15	1.70	26.62
Cook	*La Grange.	0.37	1.91	2.06	0.34	5.98	1.86	8.80	2.18	1.73	2.54	1.53	1.63	30.94
"	Chicago.	0.58	1.60	2.11	0.14	4.35	2.71	6.66	0.91	2.39	2.09	1.14	1.81	26.49
Lake.	*Ft. Sheridan.......	0.52	1.27	2.47	0.27	6.04	2.53	2.91	3.05	2.76	1.85	2.40	1.31	26.38
McHenry.	*Chemung	0.76	1.62	1.94	1.09	5.61	2.27	4.95	3.05	2.29	1.44	2.71	1.98	29.71
	Averages........	0.61	1.62	2.16	0.44	5.32	2.31	5.72	1.99	2.32	2.06	1.78	1.69	28.03

*** See end of table—page 159.**

Rainfall Tables—Continued.

DU PAGE RIVER.

County.	City.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1893.														
Will	*Braidwood	....	....	....	....	....	....	....	....	....	....	1.87	1.57	......
Kane	*Aurora	1.86	2.73	3.04	5.23	2.11	3.35	1 19	0.32	2.70	3.20	2.99	2.60	31.32
	Averages	1.86	2.73	3.04	5.23	2.11	3.35	1.19	0.32	2.70	3.20	2.99	2.60	31.32
1894.														
Will	*Braidwood	1.16	1.31	2.87	2.23	3.69	2.84	0.46	0.85	5.99	1.18	1.68	1.00	25.26
Kane	*Aurora	2.76	1.95	3.17	2.49	2.76	1.87	0.62	1.79	7.07	1.68	1.93	0.96	29.05
	Averages	1.96	1.63	3.02	2.36	3.22	2.35	0.54	1.32	6.53	1.43	1.80	0.98	27.15
1895.														
Will	*Joliet	*1.67*	*0.59*	*1.09*	*1.70*	1.95	1.26	4.32	2.96	0.93	0.67	2.90	6.62	26.66
Will	*Braidwood	1.82	0.67	1.04	1.92	....	....	....	....	....	....	....	....	......
Kane	*Aurora	1.53	0.50	1.14	1.48	3.34	1.66	3.83	4.80	1.17	1.11	5.41	5.89	31.86
DuPage	Wheaton	*1.67*	*0.59*	*1.09*	*1.70*	2.95	1.39	3.47	4.99	1.52	1.16	5.00	5.78	31.31
	Averages	1.62	0.56	1.11	1.63	2.75	1.44	3 87	4.25	1.21	0.98	4.43	6.10	29,94
1896.														
Will	*Joliet	1.14	2.07	1.15	2.82	5.28	3.89	4.97	2.75	6.69	0.86	2.96	0.36	34.94
Kane	*Aurora	1.06	1.92	1.73	3.96	6.55	2.34	5.60	2.56	7.24	0.29	3.97	0.24	37.46
DuPage	Wheaton	1.09	2.30	2.11	4.50	7.07	2.83	5.14	2.48	9.09	0.53	3.78	0.55	41.47
	Averages	1.09	2.10	1.66	3.76	6.30	3.02	5.24	2.60	7.68	0.56	3.57	0.38	37.95
1897.														
Will	Joliet	6.67	1.84	3.80	2.87	1.25	5.19	1.59	0.55	0.63	0.44	4.42	1.68	30.93
Kane	*Aurora	7.03	2.12	4.85	2.88	1.27	5.31	5.01	2.79	0.89	0.33	4.11	1.67	38.26
DuPage	Wheaton	6.61	2.27	5.43	4.36	1.02	4.22	3.09	1.11	1.10	0.49	2.97	0.99	33.66
	Averages	6.77	2.08	4.69	3.37	1.18	4.91	3.23	1.48	0.87	0.42	3.83	1.45	34.28
1898.														
Wili	Joliet	4.05	2.28	6.12	1.42	3 82	7.89	1.59	4.69	3.20	4.53	2.61	2.15	44.35
Kane	*Aurora	5.17	3.19	5.65	1.49	4.98	5.86	1.13	4.63	4.29	5.30	2.92	1.99	46.60
DuPage	Wheaton	3.67	2 20	6.04	1.31	4.20	6.03	1.90	5.69	4.65	5.13	2.34	1.86	45.02
	Averages	4.30	2.56	5.94	1.41	4.33	6.59	1.54	5.00	4.05	4.99	2.62	2.00	45.32
1899.														
Will	Joliet	0.82	1.68	2.23	0.35	4.69	2.17	5.26	1.74	2.44	1.39	1.15	1.70	26.62
Kane	*Aurora	0.72	2.15	3.23	0.61	9.48	1.97	5.54	1.52	2.35	2.39	1.12	1.71	32.79
DuPage	Wheaton	0.74	1.78	2.36	0.41	7.15	1.39	6.66	1.96	2.21	2.12	1.41	1.86	30.05
	Averages	0.76	1.87	2.60	0.46	7.10	1.84	5.82	1.74	2.33	2 30	1.26	1.75	29.82

*** See end of table—page 159.**

Rainfall Tables—Continued.

KANKAKEE RIVER.

County.	City.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1890.														
Iroquois	Watseka	4.79	1.77	3.28	3.86	5.37	5.78	1.57	2.70	2.08	3.73	1.56	0.25	36.74
1891.														
Porter, Ind	Valparaiso	2.09	1.95	1.97	2.78	2.00	2.42	2.47	4.50	0.34	0.39	4.14	2.41	27.46
1892														
Kankakee	Kankakee	....	....	....	....	10.09	4.67	2.51	2.24	2.03	0.86	2.96	....	......
Iroquois	Watseka	*0.96*	*2.41*	2.27	7.33	9.47	3.98	1.35	2.42	2.51	0.52	1.95	1.44	36.61
Champaign	*Rantoul	*0.96*	2.41	2.28	6.04	8.17	4.38	3.51	1.56	0.93	0.62	4.56	1.39	36.81
	Averages	0.96	2.41	2.28	6.68	8.82	4.18	2.43	1 99	1.72	0.57	3.26	1.42	36.71
1893.														
Will	Braidwood	....	....	....	....	......	....	....	....	....	....	1.87	1.57	......
Kankakee	Kankakee	1.00	0.38	1.13	5.45	4.83	1.28	T.	0.55	1.69	1.70	*2.03*	*1.91*	21.95
Iroquois	Watseka	1.85	6.70	3.15	6.95	5.42	1.35	....	....	....	....	....	....	......
Champaign	*Rantoul	1.60	3.57	2.60	7.23	3.89	1.11	0.38	0.20	4.38	0.76	2.19	2.25	30.16
	Averages	1.30	1.97	1.86	6.34	4.36	1.19	0.19	0.38	3.04	1.23	2.11	2.08	26.06
1894.														
Will	Braidwood	1.16	1.31	2.87	2.23	3.69	2.84	0.46	0.85	5.99	1.18	1.68	1.00	25.26
Kankakee	Kankakee	2.35	1.67	2.04	3.54	3.29	1.11	0.85	1.30	8.44	0.50	2.20	0.94	28.23
Champaign	*Rantoul	1.91	1.77	2.75	3.58	4.39	2.37	0.41	2.45	5.21	0.39	1.58	1.16	27.97
	Averages	1.81	1.58	2.55	3.12	3.79	2.11	0.57	1.53	6.55	0.69	1.82	1.03	27.15
1895.														
Will	*Joliet	*1.28*	*0.38*	*0.88*	*2.58*	1.95	1.26	4.32	2.96	0.93	0.67	2.90	6.62	26.73
Will	Braidwood	1.82	0.67	1.04	1.92	......	....	....	....	....	....	....	....	......
Kankakee	Kankakee	1.00	0.19	1.02	2.81	2.64	1.11	2.53	2.61	1.79	1.52	3.02	5.81	26.05
Iroquois	Gilman	0.87	T.	0.53	3.03	1.35	1.29	5.09	1.93	3.46	1.17	2.80	7.91	29.43
Champaign	*Rantoul	1.34	0.65	0.95	2.55	1.41	3.40	7.47	1.39	5.42	0.47	3.25	6.82	35.12
	Averages	1.12	0.30	0.84	2.74	1.84	1.77	4.85	2.22	2.90	0.96	2.99	6.79	29.33
1896.														
Will	*Joliet	1.14	2.07	1.15	2.82	5.28	3.89	4.97	2.75	6.69	0.86	2.96	0.36	34.94
Kankakee	Kankakee	1.09	*1.80*	0.53	1.93	5.53	5.64	7.31	4.99	5.82	*0.44*	1.95	0.17	37.20
Iroquois	Gilman	1.30	1.94	0.89	....	......	....	....	....	....	....	....	....	......
Iroquois	Martinton	....	....	....	....	......	4.42	7.02	3.62	5.50	0.25	1.98	0.13	......
Champaign	*Rantoul	0.86	1.38	0.87	1.68	4.95	4.08	6.86	3.83	5.73	0.22	2.25	0.30	33.01
	Averages	1.03	1.75	0.85	2.14	5.25	4.54	6.38	3.86	6.08	0.51	2.39	0.28	35.05
1897.														
Will	*Joliet	6.67	1.84	3.80	2.87	1.25	5.19	1.59	0.55	0.63	0.44	4.42	1.68	30.93
Kankakee	Kankakee	....	....	....	....	1.51	3.32	2.15	0.36	0.20	1.60	3.63	....	......
Iroquois	Martinton	3.61	1.37	3.96	2.26	1.78	4.44	1.67	1.28	0.29	0.61	5.71	2.20	29.18
Champaign	*Rantoul	3.88	1.18	3.41	3.54	2.23	6.73	5.39	0.58	0.68	0.58	3.80	2.32	34.32
	Averages	4.72	1.46	3.73	2.89	1.75	5.45	2.88	0.80	0.54	0.54	4.64	2.07	31.48

* See end of table—page 159.

Rainfall Tables—Continued.

County.	City.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1898.														
Will	*Joliet	4.05	2.28	6.12	1.42	3.82	7.89	1.59	4.69	3.20	4.53	2.61	2.15	44.35
Cook	Glenwood	3.16	2.11	5.05	1.51	3.66	3.89	3.97	4 85	3.43	4.30	2.48	1.79	40.20
Kankakee	Kankakee	*3.53*	*2.01*	7.69	1.31	5.66	1.72	1.69	4.20	5.80	4.18	2.33	1.17	41.29
Iroquois	Martinton	3.44	1.90	4.38	1.98	5.66	2.65	1.11	4.03	5.77	4.36	2.81	1.80	39.89
Champaign	*Rantoul	3.46	1.76	7.20	2.04	5.94	4.99	1.87	3.87	3.86	4.58	3.28	1.98	44.83
	Averages	3.53	2.01	6.09	1.65	4.95	4.23	2.05	4.33	4.41	4.39	2.70	1.78	42.11
1899.														
Will	*Joliet	0.82	1.68	2.23	0.35	4.69	2.17	5.26	1.74	2.44	2.39	1.15	1.70	26.62
Kankakee	Kankakee	1.20	....	....	0.41	3.90	2.31	3.78	2.20	2.83	....	....	2.15	......
Iroquois	Martinton	1.37	0.89	2.14	0.20	4.02	2.22	2.55	2.19	2.30	3.17	1.84	3.11	26.00
Champaign	*Rantoul	2.23	1.66	3.49	0.88	5.81	1.81	3.10	2.61	2.59	4.50	1.65	1.58	31.91
	Averages	1.47	1.41	2.62	0.48	4.84	2.07	3.64	2.18	2.44	3.35	1.55	2.13	28.18

FOX RIVER.

County.	City.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1890														
LaSalle	Ottawa	2.59	1.40	3.33	1.87	3.99	6.87	0.34	2.72	2.48	3.89	2.06	0.27	31.81
Kendall	Oswego	2.44	1.30	2.89	2.58	5.27	6.98	1.19	2.65	2.17	4.60	1.89	0.75	34.71
DeKalb	Sandwich	2.60	1.62	2.75	2.40	5.00	7.54	0.61	3.32	2.15	4.16	1.75	0.33	34.32
DeKalb	*Sycamore	1.64	1.15	1.57	2.58	3.87	7.98	0.42	2.07	1.22	3.48	1.87	1.50	29.35
Kane	Aurora	3.24	1.43	2.88	2.50	5.05	6.81	0.91	2.57	2.10	4.83	1.94	0.89	35.15
McHenry	*Riley	2.65	1.52	2.14	2.88	4.33	9.64	0.53	3.83	0.67	5.38	1.74	1.13	36.44
	Averages	2.54	1.40	2.59	2.47	4.59	7.64	0.67	2.86	1.80	4.39	1.88	0.81	33.63
1891														
LaSalle	Ottawa	2.86	2.28	2.56	3.96	1.84	3.99	4.45	5.11	1.27	0.56	4.75	1.74	35.37
Kendall	Oswego	2.71	2.32	2.33	3.97	1.97	2.93	3.07	4.36	1.20	0.64	4.42	1.93	31.85
DeKalb	Sandwich	2.52	4.13	3.80	4.70	1.57	3.34	3.18	3.87	1.62	0.39	4.75	2.31	36.18
DeKalb	*Sycamore	1.91	1.60	1.95	4.50	2.79	3.55	2.00	2.22	0.37	0.89	4.21	2.37	28.36
Kane	Aurora	2.60	2.55	3.19	4.43	2.21	3.70	2.56	5.09	0.71	0.80	4.68	2.07	34.59
McHenry	*Riley	2.22	1.65	1.64	4.05	4.38	5.06	2.40	1.95	0.87	1.16	3.75	2.16	31.29
	Averages	2.47	2.42	2.58	4.27	2.46	3.76	2.94	3.77	1.01	0.74	4.42	2.10	32.94
1892														
LaSalle	Ottawa	1.45	1.52	3.05	3.56	13.25	9.80	4.92	0.81	2.56	0.63	2.48	1.84	45.87
Kendall	Oswego	1.74	1.17	2.32	3.45	8.05	10.51	4.71	1.71	2.32	0.96	2.11	1.97	41.02
DeKalb	*Sycamore	1.73	1.21	2.01	4.81	11.77	11.23	2.56	3.56	1.62	0.95	2.13	2.06	45.64
Kane	Aurora	1.92	1.35	2.65	3.80	8.16	12.96	4.69	2.83	2.44	1.26	1.85	2.40	46.31
McHenry	*Riley	1.73	1.22	1.49	2.83	11.05	11.21	3.76	4.42	1.43	0.72	1.64	1.71	43.21
	Averages	1.72	1.29	2.31	3.69	10.46	11.14	4.13	2.67	2.07	0.90	2.04	1.99	44.41
1893														
LaSalle	Ottawa	2.20	3.03	3.30	5.23	1.95	2.49	1.02	0.77	2.29	1.10	2.18	2.16	27.72
Kendall	Oswego	1.85	3.16	2.68	4.80	2.59	3.27	1.99	0.22	2.88	2.28	2.25	1.85	29.82
DeKalb	*Sycamore	1.83	2.12	2.22	4.59	3.25	5.04	3.65	0.46	3.83	1.13	2.74	2.19	33.05
Kane	Aurora	1.86	2.73	3.04	5.23	2.11	3.35	1.19	0.32	2.70	3.20	2.99	2.60	31.32
McHenry	*Riley	1.57	1.55	1.82	3.71	2.99	5.13	2.32	0.45	4.18	2.47	2.34	1.42	29.95
	Averages	1.86	2.52	2.61	4.71	2.58	3.86	2.03	0.44	3.18	2.04	2.50	2.04	30.37

* See end of table—page 159.

Rainfall Tables—Continued.

County.	City.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1894														
LaSalle	Ottawa	2.38	1.58	2.57	1.51	4.01	3.03	0.80	1.75	7.18	1.63	2.09	1.19	29.72
Kendall	Oswego	2.31	1.10	2.68	2.82	2.82	2.20	0.50	1.49	7.35	1.34	1.79	0.77	27.17
DeKalb	*Sycamore	2.50	1.35	3.26	2.87	3.90	1.79	0.78	0.95	7.88	1.77	1.96	0.74	29.75
Kane	Aurora	2.76	1.95	3.17	2.49	2.76	1.87	0.62	1.79	7.07	1.68	1.93	0.96	29.05
McHenry	*Riley	2.24	1.33	3.02	2.62	3.62	1.22	0.31	1.33	15.73	1.57	2.06	0.44	35.49
McHenry	*Chemung	*2.44*	*1.46*	*2.94*	3.34	3.02	3.56	0.76	1.28	8.33	1.87	2.27	0.60	31.86
	Averages	2.44	1.46	2.94	2.61	3.35	2.28	0.63	1.43	8.92	1.64	2.02	0.78	30.51
1895														
LaSalle	Ottawa	1.22	0.70	0.82	2.02	1.06	1.02	4.79	2.26	1.47	1.16	5.27	5.77	27.56
Kendall	Oswego	1.33	0.38	1.35	1.56	3.27	1.64	3.61	5.00	0.59	1.05	4.53	6.10	30.41
DeKalb	*Sycamore	1.35	0.30	1.03	1.24	2.52	2.20	3.10	3.06	0.75	0.55	3.71	3.38	23.19
Kane	Aurora	1.53	0.50	1.14	1.48	3.34	1.66	3.83	4.80	1.17	1.11	5.41	5.89	31.86
Kane	*St. Charles	....	....	....	....	2.44	1.80	2.55	4.35	2.02	....	....	6.02	......
McHenry	*Riley	2.09	0.46	1.32	1.81	2.91	1.68	3 43	3.94	2.16	0.41	2.69	3.00	25.90
McHenry	*Chemung	1.47	0.95	2.18	2.52	4.96	2.11	2.91	3.06	4.74	0.66	2.10	2.59	30.25
	Averages	1.50	0.55	1.31	1.77	3.01	1.72	3.61	3.69	1.81	0.82	3.95	4.45	28.19
1896														
LaSalle	Ottawa	1.37	1.65	1.32	3.38	4.24	2.22	8.63	2.43	9.38	0.17	3.43	0.28	38.50
Kendall	Oswego	1.09	1.90	1.71	3.48	7.52	1.75	5.32	4.03	7.51	0.31	3.30	0.15	38.07
DeKalb	*Sycamore	0.50	2.03	1.44	2.74	3.80	1.59	3.60	0.58	8.39	0.26	1.88	0.55	27.36
Kane	Aurora	1 06	1.92	1.73	3.96	6.55	2.34	5.60	2.56	7.24	0.29	3.97	0.24	37.46
Kane	*St. Charles	1.05	2.20	2.46	4.11	5.77	2.52	6.07	2.61	14.44	0.40	3.00	0.61	45.24
McHenry	*Riley	0.61	1.56	1.85	2.97	5.04	3.02	3.29	2.15	9.45	0.38	1.77	0.43	32.52
McHenry	*Chemung	0.99	1.93	3.48	6.78	4.18	3.18	5.10	2.27	8.56	1.06	2.58	0.77	40.88
	Averages	0.95	1.88	2.00	3.92	5.30	2.37	5.37	2.38	9.28	0.41	2.85	0.43	37.14
1897														
LaSalle	Ottawa	5.98	1.71	4.47	1.88	0.99	6.90	2.99	0.74	1.89	0.46	4.37	1.74	34.12
Kendall	Oswego	6.06	1.60	3.56	2.36	1.19	5.19	3.63	1.77	0.86	0.15	3.71	1.58	31.66
DeKalb	*Sycamore	4.61	1.31	4.31	3.78	1.10	6.04	3.03	1.06	0.44	0.38	3.38	0.81	30.25
Kane	Aurora	7.03	2.12	4.85	2.88	1.27	5.31	5.01	2.79	0.89	0 33	4.11	1.67	38.26
Kane	*St. Charles	6.06	1.99	4.37	3.47	1.41	2.69	3.41	1.67	0.60	0.28	3.36	1.48	30.79
McHenry	*Riley	4.45	1.49	3.87	2.59	1.08	3.23	1.57	1.24	1.15	0.48	2.52	1.50	25.17
McHenry	*Chemung	5.06	1.77	5.25	4.66	1.67	6.36	4.73	2.00	1.18	0.84	2.37	1.40	37.29
	Averages	5.61	1.71	4.38	3.09	1.24	5.10	3.48	1.61	1.00	0.42	3.40	1.45	32.50
1898														
LaSalle	Ottawa	5.24	2.38	5.21	3.12	6.72	5.80	1.30	4.31	5.90	4.73	2.88	1.42	49.01
Kendall	Oswego	3.86	2.59	4.11	1.48	5.50	4.51	2.23	3.75	3.81	4.32	2.81	1.52	40.49
DeKalb	*Sycamore	3.28	3.57	5.42	1.65	3.20	3.47	1.22	6.47	3.71	4.81	1.76	0.80	39.36
Kane	Aurora	5.17	3.19	5.65	1.49	4.98	5.86	1.13	4.63	4.29	5.30	2.92	1.99	46.60
Kane	*St. Charles	3.73	2.89	5.29	1.03	4.07	4.55	1.74	5.73	3.87	5.74	1.98	1.97	42.59
McHenry	*Riley	3.89	3.03	4.76	1.90	2.74	7.74	2.27	4.35	2.16	3.41	1.64	0.76	38.65
McHenry	*Chemung	2.89	2.73	4.25	2.20	3.71	5.97	2.54	5.66	2.72	3.41	2.09	0.89	39.06
	Averages	4.01	2.91	4.96	1.84	4.42	5.41	1.78	4 97	3.78	4.53	2.30	1.33	42.25
1899														
LaSalle	Ottawa	0.63	2.10	3.21	1.50	5.08	1.42	5.70	3.02	2.15	2.53	1.46	2.03	30.83
Kendall	Oswego	0.37	1.67	2.70	0.46	7.28	1.55	4.83	2.27	......	....	....	....	......
DeKalb	*Sycamore	0.37	1.59	2.14	0.96	3.32	1.19	4.04	1.39	1.73	2.44	1.33	1.41	21.91
Kane	Aurora	0.72	2.15	3.23	0.61	9.48	1.97	5.54	1.52	2.35	2.39	1.12	1.71	32.79
Kane	*St. Charles	0.85	2.12	2.68	0.58	5.62	0.92	6.00	2.10	3.10	2.20	1.31	1.93	29.41
McHenry	*Riley	0.44	1.21	1.65	0.76	4.61	2.56	4.34	2.36	1.59	1.72	1.44	1.56	24.24
McHenry	*Chemung	0.76	1.62	1.94	1.09	5.61	2.27	4.95	3.05	2.29	1.44	2.71	1.98	29.71
	Averages	0.63	1.80	2.47	0.92	5.62	1.72	5.10	2.24	2.20	2.12	1.56	1.77	28.14

*** See end of table—page 159.**

Rainfall Tables—Continued.

VERMILION RIVER.

County.	City.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1890.														
LaSalle	*Ottawa	2.59	1.40	3.33	1.87	3.99	6.87	0.34	2.72	2.48	3.89	2.06	0.27	31 81
Putnam	*Hennepin	2.05	2.03	2.55	3.39	4.54	3.98	0.66	1.45	3.07	5.57	1.45	0.20	30.94
Livingston	*Dwight	4.59	1.45	3.37	3.95	5.08	7.38	0.90	2.05	1.30	4 00	1.75	0.25	36.07
"	Pontiac	4.18	1.20	3.58	4.15	3.65	5.10	0.75	1.95	0.35	2.61	1.45	0.30	29.27
	Averages	3.35	1.52	3.21	3.34	4.31	5.83	0.66	2.04	1.80	4.02	1.68	0.25	32.02
1891.														
LaSalle	*Ottawa	2.86	2.28	2.56	3.96	1.84	3.99	4.45	5.11	1.27	0.56	4.75	1.74	35.37
Putnam	*Hennepin	2.36	1.35	3.13	3 50	2.68	6.79	1.99	4.45	0.98	1.43	4.66	2.28	35.60
Livingston	Pontiac	0.95	2.45	2.88	3.45	0.47	6.07	2.65	3.95	0.20	1.40	4.70	2.40	31.57
	Averages	2.06	2.03	2.86	3.64	1.66	5.62	3.03	4.50	0.82	1.13	4.70	2.14	34.18
1892.														
LaSalle	*Ottawa	1.45	1.52	3.05	3.56	13.25	9.80	4.92	0.81	2.56	0.63	2.48	1.84	45.87
Putnam	*Hennepin	1.20	0.60	2.63	3.33	12.57	10.01	4.22	0.32	1.25	0.70	2.65	2.30	41.78
Iroquois	*Watseka	*1.33*	*1.48*	2.27	7.33	9.47	3.98	1.35	2.42	2 51	0.52	1.95	1.44	36.05
McLean	*Bloomington	*1.33*	2.31	1.48	6.41	8.27	6.86	4.68	1.16	2.70	1.25	2.62	1.21	40.28
	Averages	1.33	1.48	2.36	5.16	10.89	1.66	3.19	1.18	2.25	0.78	2.42	1.70	41.00
1893.														
LaSalle	*Ottawa	2.20	3.03	3.30	5.23	1.95	2.49	1.02	0.77	2.29	1.10	2.18	2.16	27.72
"	Streator	....	....	....	6.17	3.21	0.96	....	....	3.00	....	2.80	0.97	......
Putnam	*Hennepin	1.70	0.90	*3.19*	5.10	1.60	2.95	1.25	0.38	1.91	0.95	*2.30*	*1.04*	23.27
Iroquois	*Watseka	1.85	6.70	3.15	6.95	5,42	1.35	....	....	....	....	....	....	......
McLean	*Bloomington	1.36	3.13	3.11	8.34	5.40	0,80	1.16	0.15	2.70	0.74	1.93	1.47	30.29
	Averages	1.75	2.35	3.20	6.22	2.98	2.08	1.15	0.43	2.30	0.93	2.14	1.56	27.09
1894.														
LaSalle	*Ottawa	2.38	1.58	2.57	1.51	4.01	3.03	0.80	1.75	7.18	1.63	2.09	1.19	29.72
"	Streator	1.90	0.44	2.95	1.03	3.62	2.53	....	....	....	....	2.10	....	......
McLean	*Bloomington	2.32	1.93	3.37	2.53	3.21	1.89	1.34	0.91	5.59	0.50	2.52	1.86	27.97
	Averages	2.35	1.75	2.97	2.02	3.61	2.46	1.07	1.33	6.39	1.06	2.31	1.53	28.85
1895.														
LaSalle	*Ottawa	1.22	0.70	0.82	2.02	1.06	1.02	4.79	2.26	1.47	1.16	5.27	5.77	27.56
"	Streator	1.55	0.30	1.40	0.41	0.80	*1.66*	6.00	2.60	1.90	1.00	*4.03*	5.89	27.54
McLean	*Lexington	1.23	0.21	1.06	3.42	1.23	2.29	9.16	2.89	5.87	0.76	2.80	6.83	37.75
	Averages	1.33	0.40	1.10	1.95	1.03	1.66	6.65	2.58	3.08	0.98	4.03	6.16	30.95
1896.														
LaSalle	*Ottawa	1 37	1.65	1.32	3.38	4.24	2.22	8.63	2.43	9.38	0.17	3.43	0.28	38.50
"	Streator	1.30	1.15	0.65	2.63	5.98	3.27	5 75	1.52	3.44	0.05	2.07	0 10	27.91
Livingston	Dwight	....	....	....	...	......	3.13	4.61	2.61	5.09	0.64	3.54	0.11	.....
McLean	*Lexington	1.09	1.87	0.53	3.62	6.22	4.58	7.18	5.47	*5.83*	*0.25*	*3.00*	0.15	39 79
"	*Bloomington	0.82	2.55	2.11	2.02	6.79	3.90	6.68	4.75	5.40	0.16	2.95	0.53	38.66
	Averages	1.15	1.80	1.15	2.91	5.81	3.49	7.06	3.54	6.01	0.16	2.86	0.27	36 21

* See end of table—page 159.

Rainfall Tables—Continued.

County.	City.	January ...	February ..	March	April	May	June	July	August	September	October	November..	December..	Annual ....
1897.														
LaSalle	*Ottawa	5.98	1.71	4.47	1.88	0.99	6 90	2.99	0.74	1.89	0.46	4.37	1.74	34.12
"	Streator	5.64	1.55	4.08	1.88	1.13	6.70	2.71	1.07	1.10	0.23	4.20	1.32	31.62
Livingston ...	Dwight	5.34	1.40	3.67	2.74	1.81	5.25	2.50	1.60	0.81	0.44	4.77	1.59	31.82
McLean.......	*Lexington	5.67	2 51	4.01	2.70	1.68	1.59	6.38	0.50	0.70	0.32	4.19	1.47	31.72
"	*Bloomington.....	5.41	1.77	4.09	3.92	1.90	3.49	3 91	1.50	2.08	0.48	5.00	2.00	35.55
	Averages......	5.61	1.79	4.06	2.62	1.50	4.79	3.70	1.08	1.31	0.38	4.50	1.62	32.96
1898.														
LaSalle	Ottawa	5.24	2.38	5.21	3.12	6.72	5.80	1.30	4.31	5.90	4.73	2.88	1.42	49.01
"	Streator	3.43	1.62	6.93	3.00	6.00	3.24	6.62	2.96	4.20	2.99	2.47	0.77	38.23
Livingston ...	Dwight	3.80	2.07	6.64	2.95	6.12	3.79	0.29	3.35	4.86	4.42	2.50	1.26	42.05
McLean.......	*Lexington	4.62	2.11	5.17	2.13	6.09	2.21	1.32	2.44	5.23	4.06	2.09	1.18	38.65
"	*Bloomington.....	4.00	1.77	5.65	2.66	9.42	4.02	4.40	1.85	6.49	4.31	2.28	1.92	48.77
	Averages......	4.22	1.99	5.92	2.77	6.87	3.81	1.59	2.98	5.34	4.10	2.44	1.31	43.34
1889.														
LaSalle	*Ottawa	0.63	2.10	3.21	1.50	5.08	1.42	5.70	3.02	2.15	2.53	1.46	2.03	30.83
"	Streator	1.28	1.82	2.00	0.45	2.50	1.82	5.22	1.69	2 73	2.47	1.23	1 93	25.14
Livingston ...	Dwight	0.80	2.13	1.76	0.70	2.08	5.07	4.73	2.29	2.57	2.31	2.03	2.06	28.53
McLean.......	*Bloomington.....	1.52	2.20	4.72	0.82	4.06	4.05	1.92	2.15	1.98	2.69	1.67	2.15	29.93
	Averages......	1.06	2.06	2.92	0.87	3.43	3.09	4.39	2.29	2.36	2 50	1.59	2.04	28.60

MACKINAW RIVER.

County.	City.	January...	February ..	March	April........	May	June	July........	August	September.	October	November..	December.	Annual ....
1890														
Tazewell	*East Peoria...........	3.12	1.57	3.13	2.19	2.99	2.45	1.53	2.29	2.03	2.42	2.14	0.47	26.33
1891														
Tazewell	*East Peoria ,..........	2.16	2.25	3.60	3.80	1.93	5.72	4.46	8.47	1.32	0.71	4.32	2.96	41.70
1892														
Tazewell	*East Peoria	0.96	4.31	1.79	6.81	8.52	5.37	3.38	1.54	2.61	1.20	2.51	1.08	40.08
McLean.	*Bloomington.........	0.83	2.31	1.48	6.41	8.27	6.86	4.68	1.16	2.70	1.25	2.62	1.21	39.77
McLean.......	*Ellsworth	0.70	2.75	2.33	7.50	7.60	6.80	3.20	4.30	3.00	0.80	2.40	1.30	42.68
	Averages..........	0.83	3.12	1.87	6.91	8.13	6.34	3.75	2.33	2.77	1.09	2.51	1.19	40.84
1893														
Tazewell	*East Peoria	1.47	4.50	3.38	8.51	4.01	4.29	1.56	0.53	3.53	0.27	2.39	2.32	36.76
McLean.......	*Bloomington.........	1.36	3.13	3.11	8.34	5.40	0.80	1.16	0.15	2.70	0.74	1.93	1.47	30.29
	Averages..........	1.42	3.81	3.24	8.43	4.71	2.54	1,36	0.34	3.12	0.50	2.16	1.89	33.52
1894														
Tazewell	*East Peoria	2.44	1.06	2.91	2.04	2.80	3.24	2.53	0.51	5.38	0.31	2 26	2.15	27.63
McLean.......	*Bloomington.........	2.32	1.93	3.37	2.53	3.21	1.89	1 34	0.91	5.59	0.50	2.52	1.86	27.97
	Averages..........	2.38	1.49	3.14	2.29	3.00	2.57	1.93	0.71	5.49	0.40	2.39	2.01	27.80

*** See end of table—page 159.**

Rainfall Tables—Continued.

County.	City.	January...	February..	March.....	April......	May........	June.......	July........	August....	September.	October...	November..	December.	Annual ....
1895														
Tazewell......	*East Peoria	1.68	0.10	1.11	2.45	1.13	1.31	8.15	2.38	6.19	0.81	4.10	4.66	34.07
Woodford	*Cazenovia............	....	....	....	....	....	....	....	....	....	0.74	3.76	6.25	......
McLean.......	*Bloomington.........	2.32	1.93	3.37	2.53	3.21	1.89	1.34	0.91	5.59	0.50	2.52	1.86	27.97
McLean.......	*Lexington............	1.23	0.21	1.06	3·42	1.23	2.29	9.16	2.89	5.87	0.76	2.80	6.83	37.75
	Averages..........	1.74	0.75	1.85	2.80	1.86	1.83	6.21	2.06	5.88	0.69	3.14	4.45	33.26
1896														
Tazewell......	*East Peoria	0.75	1.80	1.26	3.74	4.77	3.47	7.97	2.84	4.09	0.34	3.18	0.27	34.48
Woodford	*Minonk...............	1.26	1.44	1.08	3.64	5.50	3.87	5 33	2.67	4.53	0.20	2.32	T.	31.84
Woodford	*Cazenovia............	1.55	1.60	1.08	4.18	5.51	3.09	5.60	5.25	5.35	*0.23*	*2.82*	*0.24*	36.50
McLean.......	*Bloomington.........	0.82	2.55	2.11	2.02	6.79	3.90	6.68	4.75	5.40	0.16	2.95	0.53	38.66
McLean.......	*Lexington............	1.09	1.87	0.53	3.62	6.22	4.58	7.18	5.47	....	....	....	0.15	......
	Averages..........	1.09	1.85	1.38	3.39	5.65	3.58	6.40	3.88	4.84	0.23	2.82	0.26	35.37
1897														
Tazewell......	*East Peoria	3.47	1.25	3.71	3.19	1.45	1·93	4.71	2.58	1.15	0.09	2.57	1.43	27.53
Woodford	*Minonk...............	5.14	1.45	3.18	2.93	1.05	2.57	2.93	0.92	1.90	0.13	3.92	1.20	27.32
McLean.......	*Bloomington.........	5.41	1.77	4.09	3 92	1.90	3.49	3.91	1.50	2.08	0.48	5.00	2.00	35.55
McLean.......	*Lexington............	5.67	2.51	4.01	2.70	1.68	1.59	6.38	0.50	0.70	0 32	4.19	1.47	31.72
	Averages..........	4.92	1.75	3.75	3.18	1.52	2.40	4.48	1.37	1.46	0.25	3.92	1.53	30.53
1898														
Wookford ...	*Minonk...............	4.21	1.78	5.00	2.87	6.84	2.92	0.58	4.76	5.47	3.86	2.13	1.04	41.46
McLean.......	*Bloomington.........	4.00	1.77	5.65	2.66	9.42	4.02	4.40	1.85	6.49	4.31	2.28	1.92	48.77
McLean.......	*Lexington	4.62	2.11	5.17	2.13	6.09	2.21	1.32	2.44	5.23	4.06	2.09	1.18	38.65
	Averages..........	4.28	1.89	5.27	2.55	7.45	3.05	2.10	3.02	5.73	4.08	2.16	1.38	42.96
1899														
Woodford	*Minonk...............	0.50	1.79	2.24	1.58	4.59	3.75	2.19	1.74	4.20	3.47	0.95	2.31	29.31
McLean.......	*Bloomington.........	1.52	2.20	4.72	0.82	4.06	4.05	1.92	2.15	1.98	2.69	1.67	2.15	29.93
	Averages..........	1.01	1.99	3·48	1.20	4.33	3.90	2.05	1.95	3.09	3.08	1.31	2.23	29.62

SPOON RIVER.

County.	City.	January...	February...	March......	April.......	May.........	June........	July.........	August....	September.	October....	November.	December..	Annual ....
1892.														
Mason	***Havana ....**	**1·65**	**1.98**	**1.54**	**4.84**	**7.69**	**3·02**	**2.29**	*0.96*	**3.01**	**0.98**	**3.25**	**1.42**	**32.63**
McDonough...	***Bushnell ....**	....	....	....	....	....	....	....	......	**2.11**	**1.19**	**2.55**	**1.63**	......
Bureau	***Walnut.............**	**2.30**	**1.48**	**3.00**	**4.06**	**8.49**	**7.84**	**5.41**	**0.96**	**3.42**	**1.06**	**1.73**	**1.94**	**41.69**
	Averages........	**1.93**	**1.73**	**2.27**	**4.45**	**8.09**	**5.43**	**3.85**	**0.96**	**3.21**	**1.02**	**2.49**	**1.68**	**37.16**
1893.														
Mason.........	***Havana ....**	**0.79**	**3.49**	**2.94**	**7.95**	**5.48**	**2.00**	**4.25**	**0.73**	**2.34**	**0.22**	**0.76**	**2.06**	**33.01**
McDonough...	***Bushnell ....**	**0.68**	**1.47**	**2.11**	**6.80**	**4.36**	**2.15**	**2.59**	**4.89**	**3.17**	**T.**	**1.92**	**1.34**	**31.48**
Warren........	***Monmouth ....**	....	**2.24**	**3.48**	....	....	....	....	......	....	....	**1.57**	....	......
Henry.........	***Galva...... ....**	**0.95**	**1.65**	**2.88**	**5.73**	**2.45**	**1.37**	**1.08**	**0.69**	**3.57**	**0.46**	**2.25**	**1.54**	**24.62**
	Averages........	**0.81**	**2.20**	**2.64**	**6.83**	**4.10**	**1.84**	**2.64**	**2.10**	**3.03**	**0.23**	**1.64**	**1.64**	**29.70**

*** See end of table—page 159.**

Rainfall Tables—Continued.

County.	City.	January...	February...	March......	April......	May.......	June.......	July.......	August	September.	October....	November.	December..	Annual ....
1894.														
Mason.........	*Havana	2.08	2.32	2.12	1 68	2.23	3.26	1.04	1.84	3 67	1.11	1.98	1.97	25.30
McDonough...	*Bushnell	1.05	1.40	2.28	2.46	2.23	4.69	0.66	0.92	6 86	1 37	2.12	1.15	27.19
Warren........	*Monmouth	1.78	1 35	2.22	2.10	2.10	2.04	1.02	2.00	5.61	1 16	1.52	:.49	24 39
Henry..........	*Galva..............	1 64	0.88	2.53	1.71	2.18	4 14	0.99	1.78	5.17	1 16	1.62	0.62	24.42
	Averages........	1.64	1 49	2.29	1.99	2.18	3 53	0.93	1.63	5.33	1 20	1 81	1.31	25.32
1895.														
Mason.........	*Havana	1.36	0.32	1.04	2.68	1.51	1.91	4 89	4.53	4.34	0.41	3.80	6.03	32.82
McDonough...	*Bushnell	1.62	0 26	0.69	3.54	2.72	1.94	6.28	3.33	6 50	0.71	3.20	*4.81*	35.60
Knox	*Knoxville	1.85	0.39	1.45	3.61	3.62	1.40	8 81	2.54	6.10	1.00	3.51	5.13	39.41
Warren........	*Monmouth	1.42	0 18	0.84	2.54	2.04	2.97	5 50	3.04	4 26	0.78	2.06	4.81	30.44
Henry..........	*Galva..............	1.33	0.19	0.35	1 03	2.53	1.57	5.58	2.74	5.17	0.87	2.18	4 20	27.74
Bureau.........	*Tiskilwa	...	....	....	....	2 70	0.70	7 89	2.38	4 44	0.78	3 31	3 89	......
	Averages........	1.49	0.27	0.88	2.68	2.48	1.96	6.21	3.24	5.28	0 76	2.95	5.00	33.20
1896.														
Mason.........	*Havana	1.21	2.13	0.98	3.15	4.31	3 25	4.87	3 36	5 30	0.58	1.84	0.33	31.31
McDonough...	*Bushnell	1.00	1.40	0.43	3.45	4.44	2 58	8.34	3 34	6.96	1 65	1.67	0.22	35 48
Knox	*Knoxville	1.15	1.40	1.57	3.62	4.19	3.65	7.25	4.91	5.28	2.06	2 30	0.38	37.76
Warren........	*Monmouth	1.10	1 35	0.68	4.50	4.76	3.56	5.79	6.68	6 02	1.76	0.81	0 35	37.36
Henry..........	*Galva..............	1 17	0.80	0.79	4.24	5.25	3 10	9.45	3.69	6 68	1.30	1.42	0.30	38.19
Bureau.........	*Tiskilwa............	1.16	1.59	1.01	4.28	4.71	2 81	5 57	2.50	6.70	0.76	1.78	0.17	33.04
	Averages........	1.13	1.44	0.91	3.87	4.61	3.16	6.88	4.08	6 16	1.35	1.64	0.29	35.52
1897.														
Mason.........	*Havana	6.66	1.32	4.53	3.74	1.08	3.58	5.22	1.22	0.51	0.08	3.41	1.82	33.17
McDonough...	*Bu-hnell	5.20	0.69	4 43	3 90	1.11	2.82	4.68	0.53	1 16	0.21	2.77	1.69	29.19
Knox	*Knoxville	6 32	0 89	5.67	4.18	1.20	2.38	4.45	1 01	2.05	0.20	2 47	1.47	32.29
Warren........	*Monmouth	5.14	0.82	2.63	3. 5	0.94	2.00	5.26	0.65	2.78	0.13	1.87	1.69	27.16
Henry..........	*Galva..............	4.91	1.23	4.64	2 61	1.06	0.92	3.60	1.01	2.46	0.23	2.00	1.08	25.75
Bureau.........	*Tiskilwa............	5.85	1.27	4.55	2.77	1 42	3 34	2.38	1.48	2 62	0 36	3.36	1.24	30.64
	Averages........	5.68	1.05	4 41	3.41	1.13	2.51	4.26	0 98	1 93	0.20	2.65	1.50	29.70
1898.														
Mason.........	*Havana	4.64	2.08	4.84	2.90	7.63	4.58	2.49	2.78	6.92	2 55	2.24	1.45	45.10
Knox	*Knoxville	5 30	1.86	5 90	3.85	7.98	5 02	0.97	10.18	5 69	2.48	2.67	0.83	52.73
Warren........	*Monmouth	3.20	1.38	3 65	2.73	6.60	4 67	1.50	9.23	7.15	2.34	1.53	0.47	44.45
Henry..........	*Galva..............	3.38	1.43	5.43	2.77	8.74	9.86	0 96	7.13	3.84	2.73	2.19	0.61	49 07
Bureau.........	*Tiskilwa............	3.76	2.43	6.17	3 50	7.30	2.85	1.17	6 97	4.58	2.63	2 93	1.09	45 38
	Averages........	4.06	1.84	5.20	3.15	7.65	5.38	1.42	7.26	5 64	2.55	2.31	0 89	47.34
1899.														
Mason.........	***Havana ....**	**0 77**	**2.21**	**3.39**	**1.26**	**7.31**	**2.24**	**7.11**	**3 26**	**4.18**	**3.34**	**2.41**	**2.73**	**40.21**
Fulton	***Astoria............**	**0.89**	**1.99**	**2.75**	**1.14**	**8.38**	**2.58**	**4.25**	**3.00**	**4.26**	**3 43**	**1.96**	**2 02**	**36.65**
Knox	***Knoxville ....**	**0.42**	**1.74**	**3.01**	**1.55**	**6.87**	**2 00**	**2 71**	**1.14**	**2.95**	**2 48**	**1.42**	**2 64**	**28.93**
Warren........	***Monmouth ....**	**0.37**	**.49**	**3.10**	**2.84**	**6 61**	**1.24**	**1.49**	**3 27**	**2 26**	**2.38**	**0.65**	**1.43**	**27.13**
Henry.........	***Galva...............**	**0 24**	**1.39**	**2.70**	**1 44**	**6.07**	**2.57**	**2.82**	**2.40**	**2.46**	**4.34**	**1 23**	**1.71**	**29 37**
Bureau........	***Tiskilwa............**	**0.38**	**1.81**	**2.83**	**1.03**	**5.25**	**3.89**	**3.48**	**1.65**	**2.55**	**3.73**	**1.15**	**1 63**	**29.38**
	Averages........	**0.51**	**1.77**	**2.96**	**1.54**	**6 75**	**2.42**	**3 65**	**2.45**	**3 11**	**3.29**	**1.47**	**2.02**	**31.94**

* See end of table—page 159.

Rainfall Tables—Continued.

SANGAMON RIVER.

County.	City.	January ...	February ...	March......	April......	May.......	June	July.......	August....	September	October ...	November.	December .	Annual ...
1890														
Cass...........	*Beardstown....	2.75	0.90	1.45	2.60	2.80	3.84	3.57	2.00	1.10	1.38	1.63	0.00	24.02
Sangamon....	Springfield	5.72	2 01	2.20	2.94	4.33	4.50	2.14	1.03	0.96	1.30	1.29	0.26	28.68
Caristian	Pana	11.65	2 01	6.32	3.41	5.57	5.25	3.33	3.66	4.66	1.16	3.50	1.12	51.64
Logan	Beason	4.35	1.36	1.99	2.71	2.56	3.70	2.50	2.90	0.80	2.90	1.10	0.20	27.07
	Averages....	6.12	1 57	2.99	2.91	3.82	4.32	2.88	2.40	1.88	1.68	1.88	0.40	32.85
1891														
Cass	*Beardstown....	0.85	3.35	5.19	3.97	3.85	2.35	3.11	4.44	1.51	2.13	4.94	0.87	36.56
Sangamon ...	Springfield	1.16	2.59	3.21	2.81	1.96	2 11	4.44	4.65	1.38	1.88	5.49	1.59	33.27
Christian.....	Pana	0.56	2.64	4.32	4 16	0.66	6.25	2.10	6.50	1.00	2.26	10.09	1.79	42.33
Logan	Beason	1.69	4.51	3.20	3.46	1.05	3.36	3.25	6.06	0.15	0.73	4.52	1.43	33.41
	Averages....	1.07	3.27	3.98	3.60	1.88	3.52	3.23	5.41	1.01	1.75	6.26	1.40	36.39
1892														
Cass	*Beardstown....	1.75	3.03	2.81	5.84	6.59	1.29	5.63	0.41	2.47	0.52	4.95	2.08	37.37
Mason..........	*Havana	1.65	1.98	1.54	4.84	7.69	3.02	2.29	*2.15*	3.01	0.98	3 25	1.42	33.82
Sangamon....	Springfield	1.14	3.41	2.69	7.19	7.51	2.51	5.63	1.89	3.48	1.05	4.19	1.78	42.47
Logan	Beason	1.45	1.86	1.58	......	...	5.93	....	....	....	....	......	....	......
Macon	Decatur	......	....	....	4.40	5.24	....	3.11	1.84	2.95	T	5.46	T	......
Christian.....	Pana.............	2.11	5.61	3.32	11.99	8.57	2.76	6.49	6.07	3.25	1.57	7.25	4.33	63.32
McLean.......	Bloomington....	*1.51*	2.31	1.48	6.41	8 27	6 86	4.68	1 16	2.70	1.25	2.62	1.21	40.46
Champaign...	*Rantoul	0.96	2.41	2.28	6.04	8.17	4.38	3.51	1.56	0.93	0.62	4.56	1.39	36.81
	Averages....	1.52	3.12	2.35	7.05	7.80	3.47	4.70	2.21	2.64	1.00	4.47	2.04	42.37
1893														
Cass	*Beardstown ...	0.06	2.01	3.69	9.11	6.18	3.34	3.00	0.41	1.49	0.40	1.45	0.62	31.76
Mason	*Havana	0.79	3.49	2.94	7.95	5.48	2.00	4.25	0.73	2.34	0.22	0 76	2.06	33.01
Sangamon ...	Springfield......	0.65	3.47	4.19	10.23	7.41	1.99	1.60	0.28	2.15	0.16	1.57	1.03	34.73
Logan	Mt. Pulaski	......	....	....	......	....	3.41	2.05	0.35	2.25	1.11	1.64	1.30	......
Macon	Decatur	0.95	....	3.82	......	....	....	....	....	....	....	1.41	....	......
McLean.......	Bloomington....	1.36	3.13	3.11	8.34	5.40	0.80	1.16	0.15	2.70	0.74	1.93	1.47	30.29
Champaign...	*Rantoul	1.60	3.57	2.60	7.23	3.89	1.11	0 38	0.20	4.38	0.76	2.19	2 25	30.16
	Averages....	0.89	3.13	3.31	8.57	5 67	1.68	2.07	0.35	2.61	0.65	1.58	1.48	31.99
1894														
Cass	*Beardstown ...	2.40	1.52	0.85	2.26	2.58	2.88	1.77	1.45	6.08	2.39	1.52	1.43	27.13
Mason	*Havana	2.08	2.32	2.12	1.68	2.23	3.26	1.04	1.84	3.67	1.11	1.98	1.97	25.30
Sangamon....	Springfield	2.51	2.58	3.09	3.36	2.80	1.56	2.06	1.86	2.94	0.85	1.63	3.10	28.34
Logan	Mt. Pulaski	2.79	2.62	3.23	2.60	2.88	1.91	3.27	1.51	4 06	0.81	1.50	2.43	29.61
Macon	Decatur	1.83	2.39	2.79	3.06	1.90	2.23	2 33	1.64	2.94	0.42	1.77	2.65	25.95
McLean.......	Bloomington....	2.32	1.93	3.37	2.53	3.21	1.89	1.34	0.91	5.69	0.50	2 52	1.86	27.97
Champaign...	*Rantoul	1.91	1.77	2.75	3.58	4.39	2 37	0.41	2.45	5.21	0.39	1.58	1.16	27.97
	Averages....	2.26	2.16	2.61	2.72	2.86	2.30	1.75	1.67	4.36	0.92	1.76	2.09	27.46
1895														
Cass...........	*Beardstown....	1.45	0.08	0.90	2.90	2.13	2.28	3.89	4.10	3.15	1.15	3.50	5.72	31.25
Mason	*Havana	1.36	0.32	1.04	2.68	1.51	1.91	4 89	4.53	4.34	0.41	3.80	6.03	32.82
Sangamon....	Spring eld	1.12	1.03	1.61	2.49	2.55	3.49	5.53	2.76	2.80	0.27	3.28	8.08	35.01
Morgan	*Alexander......	......	....	....	......	....	2.43	6.55	1.99	3.82	0.28	2.78	6.82	......
Logan	Mt. Pulaski	1.25	1.14	2 01	1.60	1.32	2.84	4.30	1 47	3.75	0.31	2.67	7.42	30.08
"	Atlanta..........	*1 27*	*0.65*	*1.40*	1.58	1.05	4.12	6.71	3.39	6.33	0.50	3.64	7.77	38.41
Macon	Decatur	1.19	0.94	1.18	2.75	1.07	4.40	3.42	1.35	4.47	0.55	3.12	6.47	30.91
Christian	Morrisonville ...	......	....	....	......	....	....	....	1.50	3 25	0.25	3.28	4.68	......
McLean.......	Bloomington....	1.26	0.39	1.68	2.55	1.13	1.75	6.71	5.12	4.28	0.61	3.74	7.62	36.84
	Averages....	1.27	0.65	1.40	2.36	1.54	2.97	5.07	3.25	4.16	0.54	3.38	7.02	33.61

* See end of table—page 159.

Rainfall Tables—Continued.

County.	City.	January ...	February ..	March......	April......	May	June	July	August	September	October....	November..	December .	Annual ....
1896														
Cass...........	*Beardstown....	1.65	1.90	0.43	3.39	3.68	3.66	13.52	1.73	5.02	2.97	1.25	0.88	40.08
Mason.........	*Havana	1.21	2.13	0.98	3.15	4.31	3 25	4.87	3.36	5.30	0.58	1.84	0.33	31.31
Sangamon....	Springfield	1.77	2.11	1.25	1.91	2.49	6.45	8.51	1.87	5.42	1.76	1.88	0.31	35.73
Logan	Mt. Pulaski.....	1.32	2.22	1.14	2.31	2.89	4.74	8.14	1.95	5.06	0.43	1.95	0.51	32.66
"	Atlanta..........	1.25	2.09	0.93	2.39	4.60	4.22	9.30	4.45	4.82	0.23	2.32	0.24	36.84
Macon	Decatur	0.97	2.91	1 44	1.56	4.75	4.00	7.12	3.00	5.80	0.66	2.81	0.32	35.34
Christian	Morrisonville...	0.43	1.41	1.25	1.98	5.05	3.65	5 98	3.07	4.44	1.19	2.59	0.44	31.48
McLean.......	Bloomington....	0.82	2.55	2.11	2.02	6.79	3.90	6.68	4.75	5.40	0.16	2.95	0.53	38.66
Champaign...	*Rantoul	0.86	1.38	0.87	1.68	4.95	4.08	6.86	3.83	5.73	0.22	2.25	0.30	33.01
	Averages....	1.14	2.08	1.16	2.27	4.39	4.22	7.89	3.08	5.22	0.91	2.21	0.43	35.01
1897														
Mason	*Havana	6.66	1.32	4.53	3.74	1.08	3.58	5.22	1.22	0.51	0.08	3.41	1.82	33.17
Sangamon....	Springfield	5.91	1.15	4.47	3.85	2.19	4.11	4.16	2.86	0 35	0 52	4.94	3.07	37.58
Logan	Mt. Pulaski	5.19	1.50	3.82	2.98	1.47	4.17	3.10	1.42	1.21	0.37	3.84	2.35	31.42
Macon	Decatur	3.83	1.23	5.08	3.87	3.21	4.22	3 03	1.40	0.41	0.28	4.57	2.54	33.67
Christian	Morrisonville...	3.35	1.20	6.02	5.27	4.09	4.99	3.60	1.36	0.29	0.12	5.29	2.78	38.36
McLean.......	Bloomington	5.41	1.77	4.09	3.92	1.90	3.49	3.91	1.50	2.08	0.48	5.00	2.00	35.55
Champaign...	*Rantoul	3.88	1.18	3.41	3.54	2 23	6.73	5.39	0.58	0.68	0.58	3.80	2.32	34.32
	Averages....	4.89	1.34	4.49	3.87	2.31	4.47	4.06	1.48	0.79	0.35	4.41	2.41	34.86
1898														
Mason.........	*Havana	4.64	2.08	4.84	2.90	7.63	4.58	2.49	2.78	6.92	2.55	2.24	1.45	45.10
Sangamon....	Springfield	5 81	2.70	9.65	3.76	5.12	4.76	2.34	4.40	6.82	6.15	2.94	1.83	56.28
Logan.........	Mt. Pulaski	4.78	2.20	9.90	2.47	5.04	3.71	0.56	2.77	5.14	4.79	2.26	1.50	45.12
Macon	Decatur	5.18	2.71	9.85	3.36	5.74	2.39	1.07	2 16	5.47	5.34	2.96	1.68	47.91
Christian	Morrisonville...	5.02	2.74	6.72	2.92	9.14	2.74	2.74	3.38	4.60	5.11	3.09	2.02	50.22
McLean.......	Bloomington....	4.00	1.77	5.65	2.66	9.42	4.02	4.40	1.85	6.49	4.31	2.28	1.92	48.77
Champaign..	*Rantoul	3.46	1.76	7.20	2.04	5.94	4 99	1.87	3.87	3.86	4.58	3.28	1.98	44.83
	Averages....	4.70	2.28	7.69	2.87	6.86	3.88	2.21	3.03	5.62	4.69	2.72	1.77	48.32
1899														
Mason	*Havana	0.77	2.21	3.39	1.26	7.31	2.24	7.11	3.26	4.18	3.34	2.41	2.73	40.21
Sangamon....	Springfield......	1.51	2.52	2.95	1.12	11.81	2.45	1.51	3.81	3.33	4.08	1.84	1.87	38.80
Christian	Pana.............	2.00	1.91	3.44	1.38	6.84	4.01	2.44	2.43	1.35	3.97	1.72	3.00	33.50
"	Morrisonville...	1.94	2.42	2 96	2.25	5.66	1.84	0.72	3.84	0.98	3.75	2.11	2.23	30.70
Logan	Mt. Pulaski	1.21	2.13	2.86	0.72	9.83	1.49	2.30	3.35	2.11	3.04	1.97	1 93	32.94
Macon	Decatur	1.89	2.43	2.58	0.59	7.01	2.11	1.02	2.56	1.50	4.20	2.01	2.37	30.28
Piatt	Monticello.......	3.60	2.18	3.30	1.13	6.02	1.42	1.25	1.87	1.87	4.34	1.41	2.37	30.76
McLean.......	Bloomington....	1.52	2.20	4.72	0.82	4.06	4.05	1.92	2.15	1.98	2.69	1.67	2.15	29.93
Champaign...	*Rantoul	2.23	1.66	3.49	0.88	5.81	1.81	3.10	2.61	2.59	4.50	1.65	1.58	31.91
	Averages....	1.85	2.18	3.30	1.13	7.15	2.38	2.26	2.88	2.21	3.77	1.87	2.25	33.22

CROOKED CREEK.

County.	City.	January....	February ..	March......	April.......	May	June	July	August....	September.	October....	November.	December.	Annual ....
1890.														
Schuyler......	**Rushville......**	**2.99**	**1.43**	**2.49**	**2.33**	**3.42**	**3.92**	**4.19**	**2.14**	**3.64**	**1.49**	**2.06**	**0.25**	**30.35**
Pike...........	***Griggsville...**	**3.31**	**1.43**	**2.75**	**2.85**	**3.31**	**5.32**	**1.47**	**1.85**	**2.47**	**1.48**	**1.40**	**0.28**	**27.92**
	Averages..	**3.15**	**1.43**	**2.62**	**2.59**	**3.36**	**4.62**	**2.83**	**2.00**	**3.05**	**1.49**	**1.73**	**0.26**	**29.13**

*** See end of table—page 159.**

Rainfall Tables—Continued.

County.	City.	January....	February..	March.....	April......	May........	June.......	July.......	August....	September.	October....	November..	December..	Annual....
1891.														
Schuyler......	Rushville......	1.05	2.09	3.29	4.49	4.74	2.57	4.78	7.94	0.61	2.34	4.93	2.13	41.16
Pike...........	*Griggsville ..	0.87	3.52	2.25	3.61	2.42	1.76	0.98	1.75	1.53	2.11	4.15	0.87	25.82
	Averages..	0.96	2.80	2.87	4.05	3.58	2.17	2.88	4.84	1.07	2.23	4.54	1.50	33.49
1892.														
Schuyler......	Rushville......	2.07	2.90	2.49	7.68	7.58	2.60	5.95	0.60	3.18	1.27	3.56	2.09	41.97
Cass...........	*Beardstown..	1.75	3.03	2.81	5.84	6.59	1.29	5.63	0.41	2.47	0.52	4.95	2.68	37.37
Pike	*Griggsville ..	2.05	3.73	2.67	6.97	8.93	1.85	5.94	0.85	3.46	1.52	3.20	0.92	42.09
McDonough ..	Bushnell	......	....	....	....	......	....	....	......	2.11	1.19	2.55	1.63	......
	Averages..	1.96	3 22	2.66	6.83	7.70	1.91	5.84	0.62	3.04	1.10	3.90	1.70	40.48
1893.														
Schuyler......	Rushville	1.16	3.02	3.77	9.10	7.36	3.03	2.45	1.91	2.96	0.22	1.72	0.81	37.51
Cass...........	*Beardstown..	0.06	2.01	3.69	9.11	6.18	3.34	3.00	0.41	1.49	0.40	1.45	0.62	31.76
Pike	*Griggsville ..	0.42	2.82	6.22	7.69	5.65	3.80	3.38	0.35	1.37	0.33	1.25	1.38	34.66
McDonough ..	Bushnell	0.68	1.47	2.11	6.80	4.36	2.15	2.59	4.89	3.17	T.	1.92	1.34	31.48
Hancock......	*Warsaw	0.40	1.66	2.25	5.25	3.47	1.59	0.88	0.95	1.77	0.22	0.77	1.08	20.29
	Averages..	0.54	2.20	3.61	7.59	5.40	2.78	2.46	1.70	2.15	0.24	1.42	1.05	31.14
1894.														
Schuyler......	Rushville	2.70	2.40	2.41	3.11	2.47	4.21	0.67	2.06	8.32	1.12	2.92	1.70	34.09
Cass...........	*Beardstown .	2.40	1.52	0.85	2.26	2.58	2.88	1.77	1.45	6.08	2.39	1.52	1.43	27.13
Pike	*Griggsville ..	2.06	2.30	2.15	2.85	2.30	2.97	0.78	1.19	2.78	0.78	1.48	1.32	22.96
McDonough ..	Bushnell	1.05	1.40	2.28	2.46	2.23	4.69	0.66	0.92	6.86	1.37	2.12	1.15	27.19
Hancock......	*Warsaw	1.74	1.20	....	1.03	0 78	1.41	0.38	0.01	1.60	....	....	....	......
	Averages..	2.05	1.91	1.92	2.67	2.39	3.69	0.97	1.41	6.01	1.41	2.01	1.40	27 84
1895.														
Schuyler......	Rushville	1.75	0.37	1.03	2.88	3.29	3.88	5.53	4.85	3.44	0.53	4.72	5.90	38.17
Pike	*Griggsville ..	1.36	0.32	3.15	2.35	2.46	3.94	6.25	2.63	3.51	0.35	2.95	6.21	35.48
McDonough ..	Bushnell	1.62	0.26	0.69	3.54	2.72	1.94	6.28	3.33	6.50	0.71	3.20	4.86	35.65
Adams	*Coatsburg....	......	....	....	....	......	....	5.88	4.90	2.29	0.34	3.36	3.68	.....
Hancock......	La Harpe......	......	....	....	....	1 40	3.13	4.89	3.24	3.25	0.34	3.40	3.65	.....
"	*Warsaw	......	....	1.29	1.63	2.66	3.08	4.20	....	......	....	....	....	......
	Averages..	1.58	0.32	1.62	2.92	2.82	3.25	6.02	3.61	4.48	0.53	3.62	5.66	36.43
1896.														
Schuyler......	Rushville	1.56	1.72	0.78	4.45	4.31	3.72	9.61	1.77	5.85	1.59	1.35	0.67	37.38
Pike	*Griggsville ..	1.50	2.16	0.56	3.05	8.10	3.29	8.10	2.72	9.32	1.60	1.65	0.38	42.43
McDonough ..	Bushnell	1.00	1.40	0.43	3.45	4.44	2.58	8.34	3.44	6.96	1.65	1.67	0.22	35.48
Adams........	*Coatsburg....	1.00	....	0.94	....	......	....	....	......	......	1.65	1.82	0.66	......
Hancock......	La Harpe......	1.26	2.14	1.18	2.35	4.80	5.16	7.80	7.96	12.28	2.00	2.53	0.99	50.45
"	*Warsaw	......	....	1.50	1.67	3.05	2.39	....	......	......	....	....	....	......
	Averages..	1.33	1.85	0.74	3.33	5.41	3.69	8.46	3.95	8.60	1.71	1.80	0.56	41.43
1897.														
Pike	*Griggsville ..	6.74	1.39	4.20	4.25	2.91	5.45	4.50	2.16	0.46	0.25	3.38	2.34	38.03
Adams........	*Coatsburg....	6 70	0.37	4.86	4.09	1.75	4 31	7 85	1.22	0.34	0 53	3.10	2.26	37.88
McDonough ..	Bushnell	5.20	0.69	4.43	3.90	1.11	2.82	4 68	0.53	1.16	0.21	2.77	1.69	29.19
Hancock......	La Harpe......	10.38	1 83	6.22	5.85	2.41	5.80	3.87	1.86	1.39	0.26	1.26	2.10	43.23
	Averages..	7.25	1.20	4.93	4.52	2.05	4.59	5.23	1.44	0.84	0.31	2.63	2.09	37.08

* See end of table— page 159.

Rainfall Tables—Continued.

County.	City.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1898.														
Pike	*Griggsville	4.46	2.19	5.78	4.95	8.30	4.94	3.56	4.49	6.83	3.01	3.66	0.97	53.14
Adams	*Coatsburg	3.71	2.26	7.09	4.83	6 63	5.43	3.09	2.11	8.89	2.80	2 89	1.43	51.16
McDonough	Bushnell	3.58	1.64	5.90	....	....	....	....	....	6.23	2.67	2.37	0 55	......
Hancock	La Harpe	2.94	1.40	5.12	3.91	8.56	2.59	2.35	10.40	6.42	3.15	1,65	0.42	48.91
	Averages	3.70	1.95	6.00	4.56	7.83	4.32	3.00	5.67	7.38	2.99	2.73	0.94	51.07
1899.														
Pike	*Griggsville	0.42	1.54	3.81	1.80	13.10	1.97	3.16	4.43	3.79	3.33	2.16	1.27	40.78
Adams	*Coatsburg	0.46	1.80	2.50	1.34	8.19	2.25	3.31	4.95	2.53	3.13	2.66	1.32	34.44
McDonough	Bushnell	0.66	2.07	2.92	3.69	7.68	3.94	2.44	4.33	3.83	2.61	1.40	1.20	36.77
Hancock	La Harpe	0.35	1.38	3.14	3.17	12.57	2.60	2.58	4.32	2.82	1.97	1.52	1.17	37.59
	Averages	0.47	1.70	3.09	2.50	10.39	2.69	2.87	4.51	3.24	2.76	1.93	1.24	37.39

MACOUPIN CREEK.

County.	City.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1890.														
Greene	*White Hall	6.70	2.55	2.12	2.09	3.02	3.81	2.09	1.63	2.04	1.05	0.94	0.43	28.47
1891.														
Greene	*White Hall	1.21	2.72	1.88	1.89	1.83	6.49	0.92	2.54	2.02	1.39	4.69	0.93	28.51
Macoupin	Carlinville	0.70	1.93	2.39	2.08	2.56	3.48	1 27	5.34	0.62	0.94	5.25	1.08	27.64
Madison	*Alton	0 68	2.09	2.49	2.22	3.78	4.70	1.65	4.40	0.87	0.61	4.99	1.44	29.92
	Averages	0.86	2.25	2.25	2.06	2.72	4.89	1.28	4.10	1.17	0.98	4.98	1.15	28.69
1892.														
Greene	*White Hall	1.75	4.09	2.30	6.29	9.20	2.59	6.16	0 87	1.99	1.44	2.79	1.94	41.41
Macoupin	Carlinville	1.52	3.77	2.42	9.34	9.90	5 72	4.13	1.91	2.23	1.78	4.42	1.69	48.83
Madison	*Alton	2.09	4.38	2.09	6.38	7.87	3.57	5.35	1.65	2.50	1,40	3.05	2.17	42.50
	Averages	1.79	4.08	2.27	7.34	8.99	3.96	5.21	1.48	2.24	1.54	3.42	1.93	44.24
1893.														
Greene	*White Hall	0.47	2.31	4.62	9.31	4.47	5.08	1.80	0.36	1.21	1.30	*1.37*	*1.45*	33.75
Macoupin	Carlinville	0.37	5 72	3.68	9.23	4.59	4.10	1.84	0.51	2.57	1.69	1.37	1.45	37.12
Madison	*Alton	0.26	3.34	5.86	8.47	5.84	3.27	1.48	1.50	....	....	....	....	......
	Averages	0.42	4.01	4.15	9.27	4.53	4.59	1.82	0.44	1.89	1.49	1.37	1.45	35.43
1894.														
Greene	Carrollton	*3.09*	*2.77*	2.37	2.02	2.32	1.90	*1.77*	*1.20*	3.76	0.93	1.38	3.47	26.98
Macoupin	Carlinville	3.09	2.77	3.15	3.12	2.33	1.42	1.77	1.20	5.23	1.07	3.46	1.90	30.51
	Averages	3.09	2.77	2.76	2.57	2.33	1.66	1.77	1.20	4.49	1.00	2.42	2.68	28.74
1895.														
Greene	Carrollton	*1.08*	0.59	1 88	2.61	2.01	*3.16*	*5.58*	3.25	3 97	0.52	2.27	6.70	33.62
Macoupin	Carlinville	1.08	1.12	1.60	2.08	1.42	3.16	5.58	2.14	3.43	0.42	2.91	6.75	31.69
	Averages	1.08	0.85	1.74	2.35	1.72	3.16	5.58	2.69	3.70	0.47	2.59	6.72	32.65

* See end of table—page 159.

Rainfall Tables—Continued.

County.	City.	January...	February...	March	April.......	May........	June.......	July........	August	September.	October....	November..	December.	Annual ....
1896.														
Greene	Carrollton.............	1.41	1.24	1.45	1.86	6.94	2.92	6.42	2.19	4.58	1.37	1.50	0.50	32.38
Macoupin.....	Carlinville	1.28	2.76	1.51	2.48	8.11	6.60	6.53	4.63	3.87	1.35	2.01	0.43	41.56
	Averages	1.34	2.00	1.48	2.17	7.53	4.76	6.47	3.41	4.23	1.36	1.75	0.47	36.97
1897.														
Greene	Carrollton.............	4.99	1.21	4.63	4.33	2.09	4.89	6 54	0.01	0 59	0.31	5.00	1.94	36.53
Macoupin.....	Carlinville	3.91	1.62	6.72	5.85	2.66	3.91	3 33	1.65	T.	0.21	5.06	2.89	37.81
	Averages..........	4.45	1.42	5.67	5.09	2.37	4.40	4.94	0.83	0.29	0.26	5.03	2.42	37.17
1898.														
Greene	Carrollton.............	5.10	2.00	6 36	5.16	7.33	2 94	4.02	3.43	4.24	3.57	1.84	1.82	47.81
Macoupin.....	Carlinville	4.98	1.96	7.49	4.30	7.58	3.66	3.68	2.68	5.39	4.60	2.63	2.16	51.11
	Averages..........	5.04	1.98	6.92	4.73	7.46	3.30	3.85	3.05	4.82	4.08	2.24	1.99	49.46
1899.														
Greene	Carrollton.............	1.25	2.01	2.75	1.30	8.01	....	....	....	....	....	....	....	......
Macoupin.....	Carlinville	1.79	2.30	3.24	1.27	6.99	1.71	2.54	6.48	2.29	3.91	2.30	2.38	37.20

MC KEE'S CREEK.

County.	City.	January ...	February ..	March......	April.......	May.........	June	July.........	August	September.	October	November..	December..	Annual.....
1890.														
Pike	*Griggsville	3.31	1.43	2.75	2.85	3.31	5.32	1.47	1.85	2.47	1.48	1.40	0.28	27.92
Schuyler	*Rushville	2.99	1.43	2,49	2.33	3.42	3.92	4.19	2.14	3.64	1.49	2.06	0.25	30.35
	Averages........	3.15	1.43	2.62	2.59	3.36	4.62	2.83	2.00	3.05	1.49	1.73	0.26	29.13
1891.														
Pike	*Griggsville	0.87	3.52	2.25	3.61	2.42	1.76	0.98	1.75	1.53	2.11	4.15	0.87	25.82
Schuyler	*Rushville	1.05	2.09	3.49	4.49	4.74	2.57	4.78	7.94	0.61	2.34	4.93	2.13	41.16
	Averages........	0.96	2.81	2.87	4.05	3.58	2.16	2.88	4.84	1.07	2.23	4.54	1.50	33.49
1892.														
Pike	*Griggsville	2.05	3.73	2.67	6.97	8 93	1.85	5.94	0.85	3.46	1.52	3.20	0.92	42.09
Schuyler	*Rushville	2.07	2.90	2.49	7.68	7.58	2.60	5 95	0.60	3.18	1.27	3.56	2.09	41.97
	Averages........	2.06	3.32	2.58	7.32	8 25	2.23	5.95	0.72	3.32	1.39	3.38	1.51	42.03
1893.														
Pike	*Griggsville	0.42	2.82	6.22	7.69	5.65	3.80	3.38	0.35	1.37	0.33	1.25	1.38	34.66
Schuyler	*Rushville	1.16	3.02	3.77	9.10	7.36	3.03	2 45	1,91	2.96	0.22	1.72	0.81	37.51
	Averages........	0.79	2.92	4.99	8.40	6.50	3.42	2.92	1.13	2.16	0.27	1.49	1.09	36.08
1894.														
Pike	*Griggsville	2.06	2.30	2.15	2.85	2.30	2.97	0.78	1.19	2.78	0.78	1.48	1 32	22.96
Schuyler	*Rushville...........	2.70	2.40	2.41	3.11	2.47	4.21	0.67	2.06	8.32	1 12	2.92	1.70	34 09
	Averages.......	2.38	2.35	2.28	2.98	2.38	3.59	0.73	1.62	5.55	0.95	2.20	1.51	28.52

*** See end of table—page 159.**

Rainfall Tables.—Continued.

County.	City.	January…	February…	March……	April……	May……	June……	July……	August…	September.	October…	November..	December..	Annual…
1895.														
Pike……….	*Griggsville……..	1.36	0.32	3.15	2.35	2.46	3.94	6.25	2.63	3.51	0.35	2.95	6.21	35.48
Schuyler…..	*Rushville……….	1.75	0.37	1.03	2.88	3.29	3.88	5.53	4.85	3.44	0.53	4.72	5.90	38.17
Adams……..	*Coatsburg……….	….	….	….	….	……	….	5.88	4.90	2.29	0.34	3.36	3.68	……
	Averages……..	1.55	0.35	2.09	2.61	2.88	3.91	5.89	3.74	3.47	0.44	3.84	6.05	36.82
1896.														
Pike……….	*Griggsville……..	1.50	2.16	0.56	3.05	8.10	3.29	8.10	2.72	9.32	1.60	1.65	0.38	42.43
Schuyler…..	*Rushville……….	1.56	1.72	0.78	4.45	4.31	3.72	9.61	1.77	5.85	1.59	1.35	0.67	37.38
Adams……..	*Coatsburg……….	1.00	….	0.94	….	……	….	….	….	….	1.65	1.82	0.66	……
	Averages……..	1.53	1.94	0.67	3.76	6.20	3.51	8.85	2.25	7.58	1.60	1.50	0.53	39.91
1897.														
Pike……….	*Griggsville……..	6.74	1.39	4.20	4.25	2.91	5.45	4.50	2.16	0.46	0.25	3.38	2.34	38.03
Adams……..	*Coatsburg……….	6.70	0.87	4.86	4.09	1.75	4.31	7.85	1.22	0.34	0.53	3.10	2.26	37.88
	Averages……..	6.72	1.13	4.53	4.17	2.33	4.88	6.17	1.69	0.40	0.39	3.24	2.30	37.95
1898.														
Pike……….	*Griggsville……..	4.46	2.19	5.78	4.95	8.30	4.94	3.56	4.49	6.83	3.01	3.66	0.97	53.14
Adams……..	*Coatsburg……….	3.71	2.26	7.09	4.83	6.63	5.43	3.09	2.11	8.89	2.80	2.89	1 43	51.16
	Averages……..	4.08	2.23	6.44	4.89	7.46	5.18	3.33	3.30	7.86	2.90	3.28	1.20	52.15
1899.														
Pike……….	*Griggsville……..	0.42	1.54	3.81	1.80	13.10	1.97	3.16	4.43	3.79	3.33	2.16	1.27	40.78
Adams……..	*Coatsburg……….	0.46	1.80	2.50	1.34	8.19	2.26	3.31	4.95	2.53	3.13	2.66	1.32	34.44
	Averages……..	0.44	1.67	3.15	1.57	10.65	2.11	3.23	4.69	3.16	3.23	2.41	1.30	37.61

MONTHLY PRECIPITATION ON ILLINOIS RIVER DIRECT.

County.	City.	January…	February…	March……	April……	May……	June……	July……	August…	September.	October…	November..	December..	Annual…
1890.														
Pike……….	Griggsville……	3.31	1.43	2.75	2.85	3.31	5.32	1.47	1.85	2.47	1.48	1.40	0.28	27.92
Cass……….	Beardstown….	2.75	0.90	1 45	2.60	2.80	3.84	3.57	2.00	1.10	1.38	1.63	0.00	24.02
Peoria………	Peoria…………	2.84	1.35	2.80	1.76	2.63	2.49	1.08	2.35	2.10	3.31	1.87	0.25	24.83
Marshall…..	Lacon……….	2.77	1.86	4.18	1.69	3.95	3.84	0 55	1.85	1.96	3.95	2.17	0.87	29.64
Putnam…….	Hennepin…….	2.05	2.03	2.55	3.39	4.54	3.98	0.66	1.45	3.07	5.57	1.45	0.20	30 94
LaSalle……	Ottawa……….	2.59	1.40	3.33	1.87	3.99	6.87	0.34	2.72	2.48	3.89	2.06	0.27	31.81
	Averages….	2.72	1.49	2.84	2.36	3.54	4.39	1.28	2.04	2.19	3.26	1.77	0.31	28.19
1891.														
Pike……….	Griggsville……	0.87	3.52	2.25	3.61	2.42	1.76	0.98	1.75	1.53	2.11	4.15	0.87	25.82
Cass……….	Beardstown….	0.85	3.35	5.19	3.97	3.85	2.35	3.11	4 44	1.51	2.13	4.94	0.87	36.56
Peoria………	Peoria…………	1.77	2.17	2.87	3 59	2.00	3.54	2.83	5.82	1.96	0.74	2.29	2.36	31.94
Marshall…..	Lacon……….	2.45	2.31	3.34	3.94	1.55	6.83	1.45	6.09	0.39	1.40	4.50	2.00	36.25
Putnam…….	Hennepin…….	2.36	1.35	3.13	3.50	2.68	6.79	1.99	4.45	0.98	1.43	4.66	2.28	35.60
LaSalle……	Ottawa……….	2.86	2.28	2.56	3.96	1.84	3.99	4.45	5.11	1.27	0.56	4.75	1.74	35.37
	Averages….	1.86	2.49	3.23	3.76	2.39	4.21	2.47	4.61	1.27	1.40	4.21	1.69	33.59

* See end of table—page 159.

Rainfall Tables—Continued.

County.	City.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1892.														
Pike	Griggsville	2.05	3.73	2.67	6.97	8.93	1.85	5.94	0.85	3.46	1.52	3.20	0.92	42.09
Cass	Beardstown	1.75	3.03	2.81	5.84	6.59	1.29	5,63	0.41	2.47	0.52	4.95	2.08	37.37
Peoria	Peoria	1.62	2.00	2.69	4.69	7.27	6.92	3.31	0.72	2 36	1.03	3.09	1.85	37.56
Putnam	Hennepin	1.20	0.60	2.63	3.33	12.57	10.01	4.22	0.32	1.25	0.70	2.65	2.30	41.78
LaSalle	Ottawa	1.45	1.52	3.05	3.56	13.25	9.80	4.92	0.81	2.56	0.63	2.48	1.84	45.87
	Averages	1.61	2.18	2.77	4.88	9.72	5.97	4.81	0.62	2'42	0.88	3.27	1.80	40.93
1893.														
Pike	Griggsville	0.42	2.82	6.22	7.69	5.65	3.80	3.38	0.35	1.87	0.33	1.25	1.38	34.66
Cass	Beardstown	0.06	2.01	3.69	9.11	6.18	3.34	3.00	0.41	1.49	0.40	1.45	0.62	31.76
Mason	Havana	0.79	3.49	2.94	7 95	5.48	2.00	4 25	0.73	2.34	0.22	0.76	2.06	33.01
Peoria	Peoria	1.31	2.83	3.24	7.89	4.78	2.07	2.54	0.45	2.79	0.83	2.31	1.67	32.71
Putnam	Hennepin	1.70	0.90	*3.88*	5.10	1.60	2.95	1.25	0.38	1.91	0.95	*1.59*	*1.58*	23.79
LaSalle	Ottawa	2.20	3.03	3.30	5.23	1.95	2.49	1.02	0.77	2.29	1.10	2.18	2.16	27.72
	Averages	1.08	2.51	3.88	7.16	4.27	2.78	2,57	0.52	2.03	0.64	1.59	1.58	30.61
1894.														
Jersey	Grafton	*2.30*	*1.84*	*2.13*	2.33	2.03	1.94	1.35	2.15	3.75	1.89	1.90	3.04	26.65
Greene	Carrollton	*2.30*	*1.84*	2.37	2.02	2.32	1.90	*1.08*	*1.83*	3.76	0.93	1.38	3.47	25.20
Pike	Griggsville	2.06	2.50	2.15	2285	2.30	2.97	0.78	1.19	2.78	0 78	1.48	1.32	22.96
Cass	Beardstown	2 40	1.52	0.85	2.26	2.58	2.88	1.77	1.45	6.08	2.39	1.52	1.43	27.13
Mason	Havana	2.08	2.32	2.12	1.68	2.23	3.26	1.04	1.84	3.67	1.11	1.98	1.97	25.30
Peoria	Peoria	2.60	1.49	2.73	1.72	3.96	3.90	0.78	2.58	4.22	1.38	2.70	1.58	29.62
LaSalle	Ottawa	2.38	1.58	2.57	1.51	4.01	3.03	0.80	1.75	7.18	1.63	2.09	1.19	29.72
	Averages	2.30	1.84	2.13	2.05	2.78	2.84	1.08	1.83	4.49	1.45	1.87	2.00	26.65
1895.														
Jersey	Grafton	0.38	0.38	1.58	1.30	2.59	2.96	7.51	1.92	2.78	0.53	4.61	7.23	33.77
Greene	Carrollton	*1.19*	0.59	1.88	2.61	2.01	*2.13*	*6.11*	3.25	3.97	0.52	2.27	6.70	33 23
Pike	Griggsville	1.36	0.32	3.15	2.35	2.46	3.94	6.25	2.63	3.51	0.35	2.95	6.21	35.48
Cass	Beardstown	1.45	0.08	0.90	2.90	2.13	2.28	3.89	4.10	3.15	1.15	3.50	5.72	31 25
Schuyler *	Frederick	*1.19*	*0.40*	*1.46*	2.65	1.65	2.70	5.25	5.35	2.90	*0.69*	3.82	5.95	34.01
Mason	Havana	1.36	0.32	1.04	2.68	1.51	1.91	4.89	4.53	4.34	0.41	3.80	6.03	32.82
Peoria	Peoria	1.39	0.43	0.85	2.74	1.76	1.54	8.43	2.18	5.26	0.64	4.49	5.09	34.80
Bureau	Tiskilwa	*1.19*	*0.40*	*1.46*	*2.41*	2.70	0.70	7.89	2.38	4.44	0.78	3.31	3.89	31.55
LaSalle	Ottawa	1.22	0.70	0.82	2.02	1.06	1.02	4.79	2.26	1.47	1.16	5.27	5.77	27.56
	Averages	1.19	0.40	1.46	2.41	1.99	2.14	6.11	3,18	3.54	0.69	3.78	5.84	32.72
1896														
Jersey	Grafton	1.45	2,47	1.69	2.80	6.46	7.03	5.09	1.93	3.37	1.16	1.02	0.50	34.97
Greene	Carrollton	1.41	1.24	1.45	1.86	6.94	2.92	6.42	2.19	4.58	1.37	1.50	0.50	32.38
Pike	Griggsville	1.50	2.16	0.56	3.05	8.10	3.29	8.10	2.72	9.32	1.60	1.65	0.38	42.43
Morgan	Alexander	1.19	1.69	0.82	2.49	4 27	4.63	7.50	0.89	5.49	1.98	1.09	0.22	32.26
Cass	Beardstown	1.65	1.90	0.43	3.39	3.68	3.66	13.52	1.73	5.02	2.97	1.25	0.88	40.08
Schuyler	Frederick	1.40	1.70	0.95	....	....	......	......	....	....	....	....	....	......
Mason	Havana	1.21	2.13	0.98	3.15	4.31	3.25	4.87	3.36	5.30	0.58	1.84	0.33	31.31
Peoria	Peoria	1.32	1.96	1.25	4.17	5.41	2.41	7.61	4.83	4.42	0.25	2 27	0 26	36.16
Woodford	Minonk	1.26	1.44	1.08	3.64	5.50	3.87	5.33	2.67	4.53	0.20	2.32	T.	31.84
Livingston	Dwight	*1.36*	*1.81*	*1.05*	*3.22*	*5.36*	3.13	4.61	2.61	5.09	0.64	3.54	0.11	32.53
Bureau	Tiskilwa	1.16	1.59	1.01	4.28	4.71	2.81	5.57	2.50	6.70	0 76	1.78	0.17	33 04
LaSalle	Ottawa	1.37	1.65	1.32	3.38	4.24	2 22	8.63	2.43	9.38	0.17	3.43	0.28	38 50
	Averages	1.35	1.82	1.06	3.22	5.36	3.57	7.02	2.53	5.75	1.06	1.97	0.33	35.05

* See end of table—page 159.

Rainfall Tables—Continued.

County.	City.	January...	February...	March......	April.......	May.........	June........	July.........	August	September.	October....	November..	December..	Annual ....
1897														
Jersey	Grafton	2.87	2.01	6.97	6.51	1.17	4.99	3.73	1.24	0.11	0.07	3.81	2.72	36.20
Greene	Carrollton........	4.99	1.21	4.63	4.33	2.09	4.89	6.54	0.01	0.59	0 31	5.00	1.94	36.53
Pike	Griggsville.......	6.74	1.39	4.20	4.25	2.91	5.45	4.50	2.16	0.46	0.25	3.38	2.34	38.03
Morgan........	Alexander........	6.05	0.83	4.42	4.35	3.39	4.52	2.41	2.20	0.24	0.33	3.50	2.42	34.66
Mason	Havana	6.66	1.32	4.53	3.74	1.08	3.58	5.22	1.22	0.51	0.08	3.41	1.82	33 17
Peoria	Peoria............	5 39	1.19	4.70	2.87	1.29	2.11	4.65	1.02	0 93	0.04	3.48	1.16	28.83
Woodford	Minonk...........	5.14	1.45	3.18	2.93	1.05	2.57	2.93	C.92	1.90	0.13	3.92	1.20	27.32
Livingston ...	Dwight...........	5.34	1.40	3.57	2.74	1.81	5.25	2.50	1.60	0 81	0.44	4.77	1.59	31.82
Bureau	Tiskilwa	5.85	1.27	4.55	2.77	1.42	3.34	2.38	1.48	2.62	0 36	3.36	1.24	30.60
LaSalle.......	Ottawa...........	5.98	1.71	4.47	1.88	0.99	6.90	2.99	0.74	1.89	0.46	4.37	1.74	34.12
	Averages....	5.50	1.38	4.52	3.64	1.72	4.36	3.78	1.26	1.01	0.25	3.90	1.81	33.12
1898														
Jersey	Grafton	5.90	1.30	8.01	3.18	9.03	3.49	5.08	2.03	4.53	4.15	2.31	1.34	50.35
Greene........	Carrollton........	5.10	2.00	6.36	5.16	7.33	2.94	4.02	3.43	4.24	3.57	1.84	1.82	47.81
Pike	Griggsville	4.46	2.19	5.78	4.95	8.30	4.94	3.56	4.49	6 83	3.01	3.66	0.97	53.14
Scott..........	Winchester	5.75	2.90	5.55	3.87	8.50	5.21	3.30	5 13	5.62	3.75	3.00	1.79	54.37
Morgan	Alexander	4 21	2.81	5.25	3.15	5 83	5.14	2.28	3 17	5.19	3.80	2.56	1.19	44.58
Mason	Havana...........	4.64	2.08	4.84	2.90	7.63	4.58	2.49	2.78	6.92	2 55	2.24	1.45	45.10
Peoria	Peoria.	4.08	2.59	5.74	3 02	5.54	3 37	0.47	3.26	6.05	3.00	2.03	0.93	40.08
Woodford	Minonk...........	4.21	1.78	5.00	2.87	6.84	2.92	0.58	4.76	5.47	3.86	2.13	1.04	41.46
Marshall......	Henry	4.00	2.10	6.15	3.68	6.41	3.61	1.10	7.10	6.91	3.11	2.46	1.32	47.95
Livingston ...	Dwight...........	3.80	2.07	6.64	2.95	6 12	3.79	0.29	3.35	4.86	4.42	2.50	1.26	42.05
Bureau	Tiskilwa	3.76	2.43	6.17	3.50	7.30	2.85	1.17	6 97	4 58	2.63	2.93	1.09	45,38
LaSalle.......	Ottawa	5.24	2.38	5.21	3.12	6.72	5.80	1.30	4.31	5.90	4.73	2.88	1 42	49.01
	Averages....	4.60	2.22	5 89	3.53	7.13	4.05	2 14	4.23	5.59	3.55	2,55	1.30	46.77
1899														
Pike	Griggsville	0.42	1.54	3.81	1.80	13.10	1.97	3.16	4.43	3.79	3.33	2.16	1.27	40.78
Scott..........	Winchester	1.41	2.34	3.47	1.71	9.13	3 06	3.04	2.95	4.67	3.47	2.28	1.56	39.09
Morgan	Alexander........	0.96	2.19	2.05	1.18	9.15	1.91	1.84	3.92	4.29	3.07	2.31	1.48	34.35
Mason	Havana	0.77	2.21	3.39	1.26	7.31	2.24	7.11	3.26	4.18	3.34	2 41	2.73	40 21
Fulton	Astoria...........	0.89	1.99	2.75	1.14	8.38	2.58	4.25	3.00	4.26	3.43	1.96	2.02	36.65
Peoria	Peoria	0.72	1.96	2.97	1.36	6.03	2 60	1.69	1.27	5.24	2.78	2.25	2.12	30 99
Woodford	Minonk...........	0.50	1.79	2.24	1.58	4 59	3 75	2.19	1.74	4.20	3.47	0.95	2.31	29 31
Marshall......	Henry	0.33	1.94	2.26	1.06	5.64	3.00	4.57	1.63	3.12	3.45	1.97	2.48	31.45
Livingston ...	Dwight...........	0.80	2.13	1.76	0.70	2.08	5 07	4.73	2.29	2.57	2.31	2.03	2.06	28.53
LaSalle	Ottawa	0.63	2.10	3.21	1.50	5.08	1.42	5.70	3.02	2.15	2.53	1.46	2.03	30.83
LaSalle ,......	Streator..........	1.28	1.82	2.00	0.45	2.50	1.82	5.22	1.69	2.73	2.47	1.23	1.93	25.14
Bureau	Tiskilwa	0.38	1.81	2.83	1.03	5 25	3.89	3.48	1.65	2.55	3.73	1.15	1.63	29.38
	Averages....	0.76	1.98	2.73	1.23	6.52	2.78	3.91	2.57	3.65	3.11	1.85	1.97	33.05

Monthly Precipitation on Various Drainage Basins of the Illinois River.

DES PLAINES RIVER.

County.	City.	January....	February ..	March	April......	May........	June.......	July........	August ...	September.	October....	November.	December .	Annual ....
1900.														
Will...........	*Joliet	1.58	4.29	2.24	0.79	4.27	1.80	5.06	5.74	2.05	1.61	3.10	0.53	33.08
Cook...........	*LaGrange	1.30	3.38	1.84	0.95	3.78	3 40	5 64	4.81	1.95	1.12	3.32	0.32	31.81
Cook...........	Chicago	1.21	3.52	1.58	1.02	3.59	2.06	4.64	4.24	1.56	1.35	3.30	0 58	28.65
McHenry	*Chemung	1.49	3.73	1.49	1.36	1.78	2.11	4.73	6.96	4.67	2.57	2.83	0.95	34.67
	Averages........	1.39	3.73	1.79	1.03	3.36	2.34	5.02	5.44	2.55	1.66	3.14	0.59	32.05

* See end of table—page 159.

Rainfall Tables—Continued.

DU PAGE RIVER.

County.	City.	January...	February..	March	April......	May........	June.......	July.......	August	September.	October....	November.	December.	Annual ....
1900.														
Will...........	*Joliet...............	1.58	4.29	2.24	0.79	4 27	1.80	5.08	5.74	2.05	1.61	3.10	0.53	33.08
Kane.........	*Aurora.............	1.78	4.15	2.23	0.78	4.17	2.94	3.55	3.28	1.99	2 83	3.23	0.41	31.34
DuPage	Wheaton	1.43	4.09	1 66	0.93	3.33	2.84	3.97	3.53	2 39	2.29	2.77	0.60	29.83
	Averages........	1.60	4.18	2.04	0.83	3.92	2.53	4.20	4.18	2.14	2.24	3.03	0.51	31.41

KANKAKEE RIVER.

1900.														
Will...........	*Joliet...............	1.58	4.29	2 24	0.79	4.27	1.80	5.08	5.74	2.05	1.61	3.10	0.53	33.08
Iroquois	Martinton...........	0.74	4.56	3.52	1.31	4.22	2.33	4 34	5.10	2.09	1.82	5 78	0.52	36.33
Champaign...	*Rantoul	0.18	2.48	2.72	0.92	4.69	7.31	5.96	5.91	5.53	2.32	2.82	0.93	41.77
	Averages........	0.83	3.78	2.83	1.01	4.39	3.81	5.13	5.58	3.22	1.92	3.90	0.66	37.06

FOX RIVER.

1900.														
LaSalle	Ottawa..............	1.60	4.53	2.91	1.53	5.60	1.96	4.53	7.24	2 26	2.24	3.16	0.31	37.87
DeKalb	*Sycamore..........	1.63	3 00	1.96	1.15	2.83	2.22	5.60	11.17	2.79	2.27	2.22	0.53	37.38
Kane..........	Aurora	1.78	4 15	2.23	0.78	4.17	2.94	3.55	3.28	1.99	2 83	3.23	0.41	31.34
McHenry	Riley	1.48	3.12	1.35	1.36	3.08	2.43	6 03	7.09	2.58	2.74	2.00	0.42	33.68
McHenry	*Chemung	1.49	3.73	1.49	1.36	1.78	2.11	4.73	6.96	4.67	2.57	2 83	0.95	34.67
	Averages.......,	1.59	3.51	1.99	1.24	3.49	2.33	4.89	7.15	2.86	2.53	2.69	0.53	34.79

VERMILION RIVER.

1900.														
LaSalle	*Ottawa.............	1.60	4.53	2.91	1.53	5.60	1.96	4.53	7.24	2.26	2.24	3.16	0 31	37.87
LaSalle	Streator.............	1 49	3 54	2.85	1.24	2.44	1 63	3 13	7.13	2.56	2.18	2.57	0 34	31.10
Livingston ...	Dwight..............	1.76	4.50	2.87	1.09	3.72	2.99	4 49	5.03	1.99	1.69	3.35	0.42	33.90
McLean.......	*Bloomington	1.23	5.94	2.60	1.85	5.40	2.49	2.38	......	1.55	2.62	3.96	0.65	31.67
	Averages........	1.52	4.63	2.81	1.43	4.29	2.27	3.88	4.85	2.09	2.18	3.26	0.43	33.63

MACKINAW RIVER.

1900.														
Woodford.....	*Minonk.............	1.30	4.45	3.02	1.16	3.09	1.40	2.21	6.43	2 54	2.24	2 66	0 37	30.87
McLean.......	*Bloomington.......	1.23	5.94	2.60	1.85	5 40	2.49	3.38	.....	1.55	2 62	3 96	0.65	31.67
	Averages........	1.26	5.19	2.81	1.51	4.25	1.95	2.79	3.21	2.05	2.43	3.31	0 51	31.27

* See end of table—page 159.

Rainfall Tables.—Continued.

SPOON RIVER.

County.	City.	January...	February..	March	April.......	May........	June	July.........	August.....	September.	October....	November..	December .	Annual ....
1900.														
Mason	*Havana	1.88	5.54	0.72	1.01	1.33	3.48	4.13	9.02	2.65	2.00	1.57	0.40	33.73
Fulton	Astoria..............	2.00	6.99	1.17	1.09	2.72	1.30	1.82	3.89	3.53	2.90	1.16	0.34	28.91
Knox	Knoxville	1.95	3.66	3.20	1.22	3.97	0.42	3.21	4.23	3.86	2.94	2.23	0.45	31.34
Warren	*Monmouth	1.67	2.92	2.10	1.01	2.93	0.82	2.65	4.23	5.31	2.86	2.39	0 25	29.14
Henry	*Galva..............	1.71	2.49	2.95	1.35	4.28	0.51	3.69	8.21	4.65	2.61	1.63	0.16	34.24
Bureau	*Tiskilwa	1.88	3.85	3.52	1.72	4.23	1.52	2.40	7.76	4.67	2.89	2.03	0.22	36.69
	Averages........	1.85	4.24	2.27	1.23	3.24	1.34	2.98	6.22	4.11	2.70	1.84	0.30	32.34

SANGAMON RIVER.

1900.														
Mason	*Havana	1.88	5.54	0.72	1.01	1.33	3.48	4.13	9.02	2.65	2.00	1.57	0.40	33.73
Sangamon....	Springfield..........	0.88	4.85	1.50	1.06	2.49	1.45	2.89	4.44	5.15	2.63	2.61	0.41	30.36
Christian.....	Pana.................	0.51	5.31	1.66	1.32	3 20	6.17	5.49	1.98	3.36	2 00	3 63	1.21	34.94
Logan	Mt. Pulaski	0.31	5.27	1.22	1.19	2.66	3.96	5.76	6.88	4.24	2.96	4.04	0.68	39.17
Macon	Decatur	0.59	5.89	1.84	1.46	4.78	4.18	7.80	4.71	4.34	1.33	3.48	0.92	41.32
Piatt	Monticello	0.40	4.88	1.58	0.38	5.11	3.82	4.93	5.37	2.84	2.50	4.04	1.01	36.86
McLean	Bloomington........	1.23	5.94	2.60	1.85	5.40	2.49	3.38	0.00	1.55	2.62	3.96	0.65	31.67
Champaign...	*Rantoul	0.18	2.48	2 72	0.92	4.69	7.31	5.96	5.91	5.53	2.32	2.82	0.93	41.77
	Averages........	0.75	5.02	1.85	1.05	3.71	4.11	5.04	4.80	3.71	2.29	3.27	0.67	36.27

CROOKED CREEK.

1900.														
Pike	*Griggsville	1.78	6.01	1.54	1.81	4.20	2.40	3.59	1.81	5.50	2,80	1.66	0.45	33.55
Adams........	*Coatsburg	2.25	5.73	0.45	1.26	4.79	1.45	1.57	3.29	4.04	4.07	0.91	0.31	30.12
McDonough..	Bushnell	2.20	0.00	1.50	1.94	4.12	1.53	2.70	4.04	5.15	2.90	1.40	0.02	27.47
Hancock......	LaHarpe	2.15	4 26	1.55	1.52	3 50	0.53	3.06	2.85	2.90	4.70	1.38	0.25	28.65
	Averages........	2.09	4.00	1.26	1.63	4.15	1.48	2.73	3.00	4.40	3.62	1.34	0.26	29.95

MACOUPIN CREEK.

1900.														
Macoupin.....	**Carlinville ....**	**0.61**	**4.70**	**1.72**	**1.36**	**4.85**	**4.88**	**5.99**	**1.42**	**5.03**	**2.42**	**2.43**	**0.95**	**36.86**

MC KEE'S CREEK.

1900.														
Pike	***Griggsville ....**	**1.78**	**6.01**	**1.54**	**1.81**	**4 20**	**2.40**	**3 59**	**1.81**	**5 50**	**2.80**	**1.66**	**0.45**	**33.55**
Adams........	***Coatsburg..........**	**2.25**	**5.73**	**0.45**	**1.26**	**4.79**	**1.45**	**1.57**	**3.29**	**4.04**	**4.07**	**0.91**	**0.31**	**30.12**
	Averages.... ...	**2.02**	**5.87**	**0.99**	**1.54**	**4.49**	**1.93**	**2.58**	**2.55**	**4.77**	**3.44**	**1.29**	**0.38**	**31.84**

*** See end of table—page 159.**

Rainfall Tables.—Continued.

ILLINOIS RIVER DIRECT.

County.	City.	January..	February..	March	April.....	May........	June	July........	August....	September.	October....	November..	December..	Annual ....
1900.														
Pike	Griggsville	1.78	6.01	1.54	1.81	4.20	2.40	3.59	1.81	5.50	2.80	1.66	0.45	33.55
Scott..........	Winchester	0.94	5.06	0.13	1 31	3.96	4.28	4.75	1.52	5.56	3.07	1.79	0.26	32.63
Morgan.......	Alexander...........	1.10	3.46	1.47	1.13	2.75	3.09	2.74	3.69	5.29	2.86	3.05	0.24	30 87
Mason	Havana..............	1.88	5.54	0.72	1.01	1.33	3.48	4.13	9.02	2.65	2.00	1.57	0.40	33.73
Fulton	Astoria	2.00	6.99	1.17	1.09	2.72	1.30	1.82	3.89	3.53	2.90	1.16	0.34	28.91
Peoria	Peoria	1.92	5.35	1.42	1.09	5.54	1.44	2.45	5.39	2.94	2.90	1.87	0.39	32.70
Woodford	Minonk..............	1.30	4.45	3.02	1.16	3.09	1.40	2 21	6.43	2.54	2.24	2.66	0.37	30.87
Marshall......	Henry	1.82	3.67	3.15	1.68	4.76	2.52	2.79	6.79	3.64	3.94	2.25	0.14	37.15
Livingston ...	Dwight...............	1.76	4.50	2.87	1.09	3.72	2.99	4.49	5.03	1.99	1.69	3.35	0.42	33.90
LaSalle	Ottawa	1.60	4.53	2.91	1.53	5.60	1.96	4.53	7.24	2.26	2.24	3.16	0.31	37.87
LaSalle	Streator	1.49	3.54	2.85	1.24	2.44	1.63	3.13	7.13	2.56	2.18	2.57	0.34	31.10
Bureau	Tiskilwa	1.88	3.85	3.52	1.72	4.23	1.52	2.40	7.76	4.67	2.89	2.03	0.22	36.69
	Averages........	1.62	4.75	2.06	1.32	3.69	2.34	3.25	5.48	3.59	2.64	2.26	0.32	33.33

* Cities not directly on drainage basin but on contiguous territory and near enough to be considered representative of drainage basin.

Resumé of Precipitation on Illinois River Basin.

Sub-Basins.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	Total averages.
Des Plaines................	35.82	29.03	35.98	29.03	27.80	30.48	33.74	30.55	37.74	28.03	31.82
DuPage	......	......	......	31.32	27.15	29.94	37.95	34.28	45.32	29.82	33.68
Kankakee	36.74	27.46	36.71	26.06	27.15	29.33	35.05	31.48	42.11	28.18	32.03
Fox	33.63	32.94	44.41	30.37	30.51	28.19	37.14	32.50	42.25	28.14	34.01
Vermilion	32.02	34.18	41.00	27.09	28.85	30.95	36.21	32.96	43.34	28.60	33 52
Mackinaw	26.33	41.70	40.84	33.52	27.80	33.26	35.37	29.43	42.96	29 62	34.08
Spoon	......	......	37.16	29.70	25.32	33.20	35.52	29.70	47.34	31.94	33.74
Sangamon	32.35	36.39	42.37	31.99	27.46	33.61	35.01	34.86	48.31	33.22	35.56
Crooked Creek............	29.13	33.49	40.48	31.14	27.84	36.43	41.43	37.08	51.07	37.39	36.55
Macoupin Creek..........	28.47	28.69	44.24	35.43	28.74	32.65	36.97	37.17	49.46	37.20	35.90
McKee's Creek............	29.13	33 49	42.03	36.08	28.52	36.82	39.91	37.95	52.15	37.61	37.37
Illinois River direct......	28.19	33.92	40.93	30.61	26.65	32.72	35.05	33.12	46.77	33.05	34.01
Annual averages	31.18	33.13	40.56	31.03	27 82	32.29	36.61	33.42	45.73	31.90	34.36

Table Showing Yearly Variations in Rainfall of Illinois.

YEAR.	Number of Stations.	Average. (Inches.)	Range. (Inches.)
1851	5	54.1	45.4-74.5
1852	5	47.8	38.4-59.4
1853	4	38.9	30.9-45.2
1854	6	34.1	23.6-46.3
1855	6	41.7	29.1-50.5
1856	9	32.7	23.3-43.9
1857	9	34.1	27.5-39.8
1858	13	51.1	45.2-68.8
18.9	11	37.3	26.5-61.3
1860	8	33.9	25.2-56.2
1861	13	39.0	30.0-68.6
1862	13	46.7	34.9-70.4
1863	11	33.5	25.6-50.4
1864	15	31.4	24.0-38.3
1865	16	40.0	24.5-51.8
1866	17	36.9	30.2-45.3
1867	19	30.2	22.4-40.2
1868	19	38.0	25.9-45.6
1869	20	41.8	30.4-51.5
1870	21	30.0	20.3-41.3
1871	18	32.3	22.6-40.8
1872	19	31.8	24.8-39.5
1873	18	38.3	19.7-54.5
1574	20	33.2	23.8-47.5
1875	20	40.5	26.9-59.5
1876	22	45.3	34.5-62.6
1877	20	41.9	33.3-54.9
1878	20	37.9	31.2-45.6
1879	20	32.0	21.5-52.3
1880	24	39.5	30.6-53.2
1881	22	41.8	32.7-56.4
1882	24	43.8	33.0-70.8
1883	27	44.1	33.7-61.5
1884	25	42.1	32.8-66.6
1885	27	39.5	32.1-50.1
1886	33	34.0	18.9-50.6
1887	33	32.2	16.1-38.3
1888	33	37.3	26.0-62.9
1889	34	34.7	24.4-42.8
1890	34	38.3	23.5-49.8
1891	32	33.0	25.9-45.1
1892	49	41.4	31.1-63.3
1893	53	34.1	20.3-48.8
1894	75	29.3	18.2-40.4
1895	97	31.9	19.7-46.4

"The average rain-fall shown in the above table is slightly lower than that given by the United States Weather Bureau, being 37.85 inches instead of 38.10. This is due to the exceptionally low rainfall of 1893-1895, which was not included in the estimate by Mr. Harrington. The average of the above table to the close of 1891 is 38.21 inches.

"Of the forty-five years' record it will be observed that twenty-two years are above and twenty-three below the average (37.85 inches) rainfall. The period of most remarkable precipitation is that of 1875-1885, inclusive. But one year was below the normal, and the average for the period of eleven years is 40.76 inches, or nearly three inches above the normal. The succeeding ten years have been marked by equally great deficiency. Only one year has been much above the normal, while seven have been much below, and the average is but 34.62 inches, or more than three inches below the normal. This period of drought is generally considered the most severe in its effects since the settlement of the State."

The above table and notes are from Water Resources of Illinois, by Leverett.

While the hydraulics of rivers depend more upon the monthly and annual rain-fall than upon the heavy showers or continued down-pours of more or less intensity, the drainage of small areas is dependent upon adequate provisions for heavy down-pours. The following tables of heavy down-pours have been brought together as being of interest in the studying of the drainage problems of cities. The tables for excessive precipitation at Indianapolis, Ind., St. Louis, Mo., and Milwaukee, Wis., as well as the table of accumulated amounts of excessive precipitation for 5 minute periods from the same cities are from the U. S. Weather Bureau reports. The table of rainfall in excess of 4 inches in 24 hours is from Signal Service War Department reports for 1890. The table of short period down-pours has been compiled for this report from U. S. Weather Bureau reports of recent date.

Here follow tables in order above given:

Excessive Precipitation.

INDIANAPOLIS, IND.

DATE.	5 minutes.		10 minutes.		1 hour or less.		24 hours or more.	
	Amount—Inches.	Rate per hour—Inches........	Amount—inches.	Rate per hour—Inches........	Amount—Inches.	Duration—Hours and minutes...	Amount—Inches.	Duration—Hours and minutes...
1890, Jan. 1......	....	....	....	....	....	....	4.41	23.10
" June 11....	.20	2.40	.41	2.46	1.04	.25	....	....
" Aug. 26....	....	....	....	....	1.50	1.25	....	....
" Sept. 10-11.	....	....	....	....	....	....	3.25	23.02
1891, Feb. 19-20.	....	....	....	....	....	....	2.86	24.00
" Aug. 19....	.45	5.40	.65	3.90	1.60	1.00	1.64	2.15
1892, April 28....	.27	3.24	.48	2.88	.90	1.00	1.49	6.00
" May 3......	.22	2.64	.23	1.38	.24	.22	....	....
" May 30-31..	.55	6.60	.65	3.90	.92	1.00	2.73	7.56
" June 8.....	.27	3.24	.38	2.28	.44	.38	....	....
" June 18....	.25	3.00	.32	1.92	40	.50	....	....
" June 20....	.22	2.64	.34	2.04	.63	.50	....	....
" July 26.....	.30	3.60	.38	2.28	.46	1.00	....	....
" Aug. 19....	.25	3.00	.30	1.80	.38	.55	....	....
1893, April 12....	.20	2.40	.25	1.50	.30	1.00	.34	1.07
" June 20....	.45	5.40	.56	3.36	.57	1.00	.60	1.15
" June 21....	.30	3.60	.46	2.76	.58	1.00	.59	1.10
" Sept. 12....	.22	2.64	.35	2.10	.57	1.00	.85	4.27
1894, Feb. 12-13..	....	....	....	....	....	....	2.69	22.40
" May 10.....	.42	5.06	.58	3.18	.69	1.00	.71	3.40
" June 22....	.23	2.76	.32	1.92	.94	1.00	.95	1.15
" June 24....	.39	4 68	.50	3.00	.78	.45	....	....
" June 26....	.20	2.40	.40	2.40	.71	1.00	1.06	4.58
" Aug. 10....	.25	3.00	.47	2.82	.93	.48	....	....
" Oct. 2-3....	.20	2.40	.30	1.80	.65	1.00	1.87	10.33
1895, July 18.....	.20	2.40	.34	2.04	.75	.54	....	....
" July 20.....	.49	5.88	.64	3.84	.71	1.00	.74	2.25
" Aug. 3.....	.20	2.40	.26	1.56	.37	1.00	.43	2.02
" Aug. 6.....	.22	2.64	.32	1.92	.50	1.00	.55	1.50
" Sept. 3-4...	.24	2.88	.35	2.10	1.25	1.0C	6.80	8.55
" Nov. 25....	.07	.84	.11	.66	.38	1.00	2.65	24.00

Excessive Precipitation—Continued.

ST. LOUIS, MO.

Date.	5 minutes.		10 minutes.		1 hour or less.		24 hours or more.	
	Amount—Inches.	Rate per hour—Inches	Amount—Inches.	Rate per hour—Inches	Amount—Inches.	Duration—Hours and minutes	Amount—Inches.	Duration—Hours and minutes
1899, May 26	.20	2.40	.25	1.50	.27	.15		
" July 14	.20	2.40	.25	1.50	.30	1.00	.45	1.20
" Sept. 4-5	.23	2.76	.45	2.70	1.00	1.00	1.85	9.55
1890, Jan. 1							3 57	17.55
" March 27	.30	3.60	.60	3.60	.70	.25		
" May 18	.25	3.00	.50	3.00	2.25	1.00	2.28	1.05
" May 23					1.50	.30		
" June 17	.25	3.00	.35	2.10	.65	.45		
1891, June 8	.21	2.52	.35	2.10	1.03	1.00	1.25	1.22
" June 16	.25	3.00	.33	1.98	.65	1.00	1.10	3.22
" Juee 20	.23	2.76	.46	2.76	.68	1.00	.95	2.30
" Aug. 11	.35	4.20	.60	3.60	.80	1.00	.85	1.35
" Aug. 18	.25	3.00	.37	2.22	.45	1.00	.50	1.40
1892, April 24							2.52	19.20
" June 18	.20	2.40	.31	1.86	.54	.40		
" July 13	.35	4.20	.57	3.42	.75	1.00	1.35	2.12
" Aug. 7	.40	4.80	.51	3.06	.86	1.00	.94	1.52
1893, April 29-30	.17	2.04	.26	1.56	.67	1.00	2.78	8.05
" May 25-26	.28	3.36	.30	1.80	.70	1.00	3.26	16.05
" July 28	.21	2.52	.37	2.22	.85	1.00	.88	2.45
1894, May 17					1.10	1.00		
" July 28	.23	2.76	.40	2.40	.72	1.00	.92	3.06
" Sept. 4	.22	2.64	.25	1.50	.60	1.00	.98	5.00
1895, June 17	.25	3.00	.38	2.28	.53	1.00	.64	4.50
" July 29	.39	4.68	.64	3.84	.97	1.00	2.92	7.37

MILWAUKEE, WIS.

Date.	5 Minutes.		10 Minutes.		1 Hour or Less.		24 Hours or More.	
	Amount—Inches.	Rate per hour—Inches	Amount—Inches.	Rate per hour—Inches	Amount—Inches.	Duration—Hours and minutes	Amount—Inches.	Duration—Hours and minutes
1889, May 17					1.16	.50		
" July 12					.70	.30		
" Sept 4							2.59	10.55
1891, June 2-3					1.27	.35	2.53	10.45
1892, June 22	.20	2.40	.25	1.50	.30	.55		
" Aug. 24	.12	1.44	.17	1.02	.50	1.00	2.50	17.15
1893, May 11	.20	2.40	.25	1.50	.35	1.00	.48	2.15
" June 4	.25	3.00	.25	1.50	.25	.08		
" June 20					1.00	1.00	1.70	1.33
" July 9	.35	4.20	.40	2.40	.50	1.00	.58	1.57
" July 15	.35	4.20	.50	3.00	1.10	.30		
1894, June 23	.25	3.00	.40	2.40	.85	1.00	.93	2.45
" June 25	.25	3.00	.35	2.10	.60	1.00	.73	2.35
" July 14	.25	3 00	.35	2.10	.64	.40		
" Sept. 7	.30	3.60	.45	2.70	.80	1.00	1.41	7.10
" Sept. 9	.65	7.80	.70	4.20	1.00	.50		
1895, June 25					1.25	1.00	1.42	3.40
" July 18	.25	3.00	.32	1.92	.45	1.00	.54	2.30
" Aug. 23	.25	3.00	.37	2.22	.68	1.00	.83	1.47
" Aug. 27	.28	3.36	.36	2.16	.43	1.00	.47	2.35
" Sept. 15	.42	5.04	.55	3.30	.68	.53		

From United States Weather Bureau Report, 1895. Supplemental table showing accumulated amounts of excessive precipitation for each five minutes during some of the heaviest rainfalls. Stations furnished with self-registering gauge.

Station and Date.	Total Duration.		Total amount of precipitation....	Depth of Precipitation (in inches) During Periods of Time as Indicated.											
	From—	To—		5 minutes..	10 minutes.	15 minutes.	20 minutes.	25 minutes.	30 minutes.	35 minutes.	40 minutes.	45 minutes.	50 minutes.	60 minutes.	80 minutes.
Indianapolis, Ind.—															
Aug. 19, 1891	7:38 A. M.	8:23 A. M.	1.55	.15	.45	.72	.76	.78	.80	1.20	1.47	1.55	....	....	....
Aug. 10, 1894	1:57 P. M.	2:32 P. M.	0.87	.05	.20	.40	.65	.82	.85	.87	....	....	....	....	....
Sept. 4, 1895	2:18 A. M.	8:00 A. M.	6.30	....	....	....	....	....	....	....	....	....	....	....	....
St. Louis, Mo.—															
Sept. 4, 1889	9:53 P. M.	11:13 P. M.	1.17	.03	.09	.15	.25	.45	.65	.73	.88	.94	.98	1.00	1.17
June 8, 1891	12:03 A. M.	1:25 A. M.	1.25	.18	.38	.45	.53	.62	.73	.80	.85	.89	.93	1.02	1.25
Milw'kee, Wis.—															
July 15, 1893	1:18 A. M.	1:48 A. M.	1.10	.13	.45	.65	.80	1.00	1.10	....	...	....	....	....	....
Sept. 9, 1894	6:32 P. M.	7:02 P. M.	.96	.65	.70	.75	.80	.88	.96	....	....	....	....	....	....

Rainfall in Excess of Four (4) Inches in Twenty-four (24) Hours upon Territory Contiguous to the Illinois River Basin.

Station.	Date.	Amount.
St. Louis, Missouri	Oct. 21, 1847	4.6
" "	May 17, 1848	5.2
" "	June 2, 1848	6.2
" "	June 22, 1848	4.4
" "	Aug. 15, 1848	5.0
" "	June 23, 1852	4.4
" "	Aug. 15, 1855	4.2
" "	July 10, 1858	4.2
" "	Dec. 4, 1858	5.0
" "	June 22, 1859	4.2
" "	Mar. 30, 1865	4.9
" "	May 27, 1867	4.4
" "	June 10, 1873	4.1
" "	Feb. 20, 1882	4.4
" "	June 16, 1888	4.6
St. Joseph, "	Sept. 9, 1877	4.8
" "	June 10, 1879	4.3
Chicago, Illinois	July 27, 1889	4.0
" "	July 26, 1878	4.1
Beloit, Wisconsin	Sept. 9, 1875	6.1
" "	July 5, 1876	4.5
" "	July 11, 1878	4.6
Embarrass, Wisconsin	Aug. 28, 1877	4.0
Clinton, Indiana	Oct. 28, 1883	4.5
Rockford, Illinois	Aug. 28, 1886	5.3
Mattoon, Illinois	Nov. 26, 1887	5.1
" "	June 27, 1888	5.8
Vandalia, Illinois	Nov. 26, 1887	5.0
Charleston, Illinois	Nov. 27, 1887	5.2
Windsor, Illinois	June 27, 1888	4.0
Philo, Illinois	July 9, 1888	8.1
" "	June 7, 1889	4.2
Green Bay, Wisconsin	Sept. 17, 1888	4.0
Angola, Indiana	July 18, 1889	4.5

Rainfall in Excess of Four (4) Inches in Twenty-four (24) Hours upon the Illinois River Basin.

Station.	Date.	Amount.
Peoria, Illinois	July 1, 1860	4.1
" "	June 6, 1872	4.9
" "	June 8, 1889	4.1
Abingdon, Illinois	Sept. 9, 1875	4.0
" "	Sept. 5, 1876	4.3
Sandwich, "	June 8, 1874	5.0
Augusta, "	Sept. 9, 1875	4.8
" "	Sept. 18, 1876	5.3
" "	July 16, 1877	4.2
Elmira, "	Aug. 20, 1878	4.0
Mt. Sterling "	July 7, 1879	4.0
" "	July 9, 1879	4.7
Pana, "	Sept. 16, 1886	4.5
" "	June 27, 1888	4.0
Beardstown, "	Apr. 19, 1889	4.0
Wyanett, "	June 14, 1875	4.0

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The following table of downpours at various stations has been compiled from Weather Bureau reports. The interpretation of the abbreviated form is as follows: For example—

At Aurora on June 18, 1897, 1.97 inches of rain fell in 1 hour and 25 minutes; on the preceding days—.64 inches fell on the 17th and .86 inches on the 16th—while on the following day, the 19th, .39 inches fell.

Short Period Downpours at Various Points in Illinois.

[P=Preceding; F=Following.]

City.	County.	Inches.	Time—hr. min.	Date.	Remarks.
Aurora	Kane	1.97	1.25	June 18, 1897	P-day, .64; day, .86; F-day, .39
Ashton	Lee	1.70	1.0	July 3, 1899	F-day, .73
Astoria	Fulton	1.53	1.0	July 11, 1899	
Bloomington	McLean	1.13	1.0	May 30, 1898	P-day, .04; day, .20; day, .09
"	"	0.62	0.15	May 18, 1898	F-day, 1.60
Brokaw	"	5.00	1.15	May 28, 1900	
Coatsburg	Adams	1.04	0.30	June 23, 1897	P-day, .64; F-day, 1.78; day, .05
Cisne	Wayne	3.95	6.0	July 25, 1897	P-day, .06; F-day, 1.01
Cobden	Union	1.06	0.28	Sept. 5, 1898	P-day, .17; F-day, 30
Dixon	Lee	2.80	7.0	June 23, 1897	
Dwight	Livingston	1.10	1.0	June 14, 1899	
"	"	1.40	0.40	June 17, 1897	P-day, .57; F-day, 1.57; day, .48
"	"	2.26	0.50	June 26, 1899	
Elgin	Kane	5.00	6.0	June 24-5, 1898	P-day, .17
Effingham	Effingham	1.25	1.30	June 8, 1899	P-day, .40; F-day, .15
"	"	5.50	1.0	June 26, 1898	F-day, .13
Equality	Gallatin	3.33	1.0	July 22, 1899	P-day, .30; F-day, .03; day, 2.11; day, .41
Galva	Henry	0.66	0.20	Oct. 29, 1896	F-day, .53
"	"	1.40	0.20	May 27, 1898	F-day, .03; day, .84; day, .01
Hillsboro	Montgomery	1.19	1.13	July 25, 1898	P-day, .19
Havana	Mason	5.10	1.30	July 16, 1899	P-2 days, 5.05
Kishwaukee	Winnebago	2.51	15.0	June 23, 1897	
LaHarpe	Hancock	1.50	1.0	June 23, 1897	P-day, .25; F-day, .30
"	"	2.25	1.30	June 30, 1897	
Loami	Sangamon	2.23	13.0	June 23-4, 1897	P-day, .25; F-day, .19
Lanark	Carroll	1.06	0.55	June 27, 1899	F-day, .45
Mt. Vernon	Jefferson	6.07	24.0	July 19-20, 1896	F-day, .15
"	"	2.48	0.20	July 20, 1896	
"	"	3.25	3.0	June 22, 1897	F-day, .76; day, .50; day, .56
Mt. Pulaski	Logan	1.70	1.0	June 30, 1897	
"	"	1.50	0.35	June 30, 1897	

Short Period Downpours—Concluded.

City.	County.	Inches.	Time—hr. min.	Date.	Remarks.
Morrisonville	Christian	1.11	1.0	June 8, 1899	F-day, .45
Martinville	Clark	1.90	1.10	July 27, 1899	
Philo	Champaign	1.85	0.50	June 23, 1897	
"	"	1.65	1.30	May 28, 1900	F-day, 1.01; day, .10; day, .65; day, 1.41
Palestine	Crawford	1.50	1.0	June 8, 1899	P-day, .02; F-day, .50
Rantoul	Champaign	1.85	0.50	June 23, 1897	
"	"	3.53	8.0	June 8-9, 1898	F-day, .07; day, .42; day, .14; day, .03
"	"	1.00	0.40	July 17, 1898	
Robinson	Crawford	1.00	0.15	Mar. 21, 1898	P-day, 1 60; day, .72; day, .99; F-day, —
"	"	1.10	0.20	July 29, 1899	
Riley	McHenry	4.49	6.30	June 24-5, 1898	F-day, .05
"	"	1.12	0.15	July 15, 1899	P-day, 1.71
Sycamore	DeKalb	2.83	13.33	June 23, 1897	
"	"	2.62	5.0	July 15, 1899	P-day, .18
Winchester	Scott	1.51	1.0	June 14, 1899	P-day, .10; F-day, .25
Wheaton	DuPage	4.21	3.0	July 15, 1899	F-day, .08
Winnebago	Winnebago	1.32	2.0	July 24, 1899	

STAGE OF THE ILLINOIS RIVER AT PEORIA.

The following tables give the stage of the Illinois river, daily, at the Bridge Street Bridge, Peoria, Ill., for 1890 to 1900, inclusive. Following the tables of daily stages is a resumé of the stages occuring each month during the ten-year period, 1890 to 1899 inclusive, as well as the date and duration of such stage and the mean stage for each month.

The lowest stage reached was 2.6 feet October 7–12, 1890, and 2.7 feet October 16–21, 1891. The ordinary low water stage is about four feet. The highest stage was 21.9 feet May 9, 1892, which was likewise the highest stage which the river has reached for nearly half a century. The longest continuous period of comparatively low water was beginning with July 1, 1893, at a stage of 7.9 feet and continuing until December 21, 1895, when a stage of 8.9 feet was attained, a stage of 4.6 feet having been recorded three days previous. During that period of 29⅝ months a stage of eight feet was reached but twice in 1894 and once in 1895. The highest stage reached was 12.3 feet March 14, 1894. The March rise of 1894 began March 7th, and on April 10th the stage was again down to 8.1 feet; in May the highest stage was 9.2 feet, being above eight feet from the 9th to 24th. From May 26, 1894, to December 21, 1895, 19 months, the river touched eight feet but once, and then only for one day, March 5, 1895. High water prevailed later in 1892 than during any other year of the decade, being continuously above ten feet from April 6th to July 31, nearly four months.

Gauge Readings for Illinois River at Bridge Street Bridge, Peoria, Illinois.

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1890.												
1	6.2	9.0	Fro..	10.8	10.3	11.9	11.6	3.0	3.3	3.6	3.9	4.4
2	6.2	8.8	" ..	10.6	10.0	11.9	11.3	3.0	3.2	3.6	3.8	4.4
3	6.6	8.8	7.5	10.8	10.0	11.6	10.9	3.0	3.2	3.6	3.8	4.4
4	6.9	8.6	7.3	10.9	9.9	11.2	10.6	3.0	3.2	3.6	3.6	4.4
5	7.3	8.5	7.8	10.8	9.9	10.8	10.3	3.0	3.2	3.6	3.6	4.3
6	7.5	8.4	Fro..	11.8	9.9	10.5	9.9	3.0	2.2	3.6	3.9	4.3
7	7.7	8.2	" ..	11.5	9.5	10.6	9.4	3.0	3.2	2.6	4.0	4.2
8	7.9	8.1	6.9	11.8	9.1	10.5	9.0	3.0	3.8	2.6	4.0	4.2
9	8.2	7.9	6.7	12.0	9.0	10.4	9.8	3.0	3.4	2.6	4.0	4.2
10	8.9	7.7	6.7	12.3	8.8	10.3	9.6	3.0	3.4	2.6	4.0	4.1
11	9.3	7.8	6.9	12.3	8.8	11.8	8.1	3.0	3.4	2.6	4.0	4.0
12	9.6	7.8	7.0	12.4	8.8	10.0	7.5	3.0	3.4	2.6	4.0	4.0
13	9.8	7.9	8.0	13.2	8.8	9.2	7.2	3.0	3.4	3.5	4.0	4.0
14	10.0	8.0	8.4	13.0	9.5	8.9	7.0	3.0	3.4	4.1	4.0	4.0
15	10.4	8.0	9.2	13.0	9.7	9.0	7.0	3.0	3.3	4.1	4.0	4.0
16	10.9	7.9	10.0	13.0	9.8	9.5	6.5	3.0	3.3	4.4	4.0	4.0
17	11.3	8.0	9.9	13.0	10.0	10.2	6.3	3.0	3.3	4.6	4.0	3.9
18	11.9	8.0	9.8	13.0	10.0	10.8	6.1	3.0	3.3	4.6	4.1	3.9
19	12.0	8.2	9.8	13.0	10.0	11.2	5.8	3.0	3.6	4.8	4.1	3.9
20	12.3	8.2	9.5	13.0	9.9	11 5	5.6	3.0	3.6	4.9	4.1	3.9
21	11.8	8.5	9.3	13.8	9.9	11.7	5.5	3.2	3.6	4.4	4.1	3.9
22	11.4	8.5	9 5	12.7	9.9	12.4	5.3	3.3	3 6	4.3	4.2	3.9
23	11.0	8.4	9.4	12.3	9.9	12.4	5.1	3.3	3.6	4.7	4.6	3.9
24	10.8	8.1	9.3	12.0	10.0	12.5	5.0	3.3	3.6	4.9	4.4	3.9
25	10.6	8.0	9.1	11.8	10.0	13.3	4.5	3.3	3.6	4.2	4.4	3.8
26	10.6	8.0	9.1	11.8	10.3	13.3	3.9	3.3	3.6	4.2	4.5	3.8
27	10.2	8.0	9.1	11.0	10.8	13.2	3.2	3.3	3.6	4.4	4.6	3.8
28	10.0	8.0	9.6	11.0	11.3	12.7	3.0	3.3	3.6	4.3	4.6	3.8
29	9.6	......	9.6	10.8	11.5	12.4	3.0	3.3	3.6	4.2	4.6	3.8
30	9.4	......	9.5	10.6	11.6	12.0	3.0	3.3	3.6	4.1	4.4	3.8
31	9.2	.....	10.0	......	11 7	......	3.0	3.3	......	4.0	......	......
Averages	9.5	8.2	7.6	12.0	10.0	11.2	6.9	3.1	3.4	3.5	4.1	4.0
1891.												
1	3.8	4.0	8.9	10.3	12.8	4.9	7.1	3.2	3.2	3.0	2.9	4.9
2	3.8	3.9	9.0	10.7	12.5	4.8	6.9	3.2	3.2	3.0	3.0	4.8
3	4.4	3.9	8.5	10.7	12.0	4.7	6.5	3.4	3.2	3.0	3.0	4.8
4	4.6	4.1	8.4	11.1	11.9	4.8	6.1	3.3	3.1	3.0	3.2	4.7
5	4.6	4.1	8.2	11.5	11.5	4.8	5.9	3.2	3.3	3.0	3.1	4.8
6	4.6	4.0	7.0	11.5	11.6	4.8	5.5	3.1	3.4	3.0	3.3	5.1
7	4.7	4.0	7.9	11.3	11.0	4.8	5.3	3.1	3.4	3.0	3.3	5 2
8	4.9	4.0	8.6	11.6	10.2	5.0	5.3	3.1	3.3	2.9	3 5	5.3
9	4.9	4.0	8.6	11.5	10.0	5.5	5.3	3.1	3.3	2.9	3.6	5.2
10	4.9	4.0	8.0	11.6	9.9	5.9	5.2	3.1	3.2	2.9	3.7	5.1
11	4.8	4.1	7.5	11.6	9.7	6.1	5.1	3.3	3.0	2.8	3.8	5.2
12	4.8	4.1	6.7	11.7	9.5	6.2	4.9	3.3	3.0	2.8	3.7	5.3
13	4.8	4.1	7.0	12.2	9.5	6.8	4.7	3.3	3.0	2.8	3.8	5.4
14	4.5	4.1	7.4	14.0	8.8	6.9	4.7	3.5	3.0	2.8	3.8	5.5
15	4.3	4.3	7.6	14.8	8.8	6.9	4.3	3.7	2.9	2.8	3.8	5.5
16	4.3	4.3	7.9	14.9	8.3	6.9	4.2	3.8	2.9	2.7	3.8	5.6
17	4.3	4.3	7.3	15.0	8.0	6.7	4.3	3.8	3.0	2.7	3.7	5.6
18	4.3	4.3	7.8	15.0	7.8	6.7	4.1	3.9	2.9	2.7	3.7	5.7
19	4.3	4.3	8.0	15.0	7.4	7.0	4.1	3.9	3.0	2.7	3.7	5.7
20	4.3	4.0	8.2	14.9	7.0	8.0	4.1	3.7	3.0	2.7	3.7	5.8
21	4.3	4.0	8.2	14.9	6.8	8.2	4.1	3.5	3.0	2.7	3.8	5.8
22	4.1	4.1	8.2	14.9	6.6	8.0	3.9	3.3	3.0	2.8	3.8	5.8
23	4.0	4.1	8.2	14.7	6.6	8.6	3.8	3.3	3.0	2.8	3.8	5.8
24	4.0	5.5	8.6	14.6	6.3	8.9	3.7	3.3	3.0	2.8	4.4	5.9
25	4.0	6.4	8.9	14.5	5.9	8.9	3.6	3.2	3 0	2.8	4.7	5.9
26	4.0	7.4	9.0	14.0	5.9	8.7	3.6	3.2	3.0	2.8	4.8	5.9
27	4.0	8.4	9.2	13.9	5.8	8.5	3.4	3.2	3.0	2.8	4.6	5.7
28	4 0	8.6	9.4	13.9	5.6	8.0	3.3	3.3	3.0	2.8	5.0	5.7
29	4.0	......	9.6	13.5	5.5	7.9	3.3	3.3	3.0	2.8	5.0	5.4
30	4.0	......	9.7	13.0	5.0	7 5	3.4	3.2	3.0	2.8	5.0	5.6
31	4.0	......	10.0	......	4.9	......	3.3	3.2	......	2.8	......	5.5
Averages	4.3	4.7	8.3	13.1	8.5	6.7	4.6	3.4	3.1	2.8	3.8	5.4

Gauge Readings for Illinois River—Continued.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1892.												
1	5.3	*4.7	7.7	8.1	11.1	17.0	17.5	9.9	4.4	4.4	4.0	4.5
2	5.3	4.7	7.9	8.2	10.9	16.8	17.0	9.6	4.4	4.4	4.0	4.5
3	5.7	4.7	7.8	8.3	11.3	16.8	16.8	9.2	4.4	4.4	4.0	4.5
4	5.8	4.8	7.7	8.5	12.0	16.8	16.9	9.0	4.3	4.4	4.1	4.5
5	5.6	5.0	7.9	9.9	14.1	16.7	17.3	8.8	4.3	4.4	4.2	4.5
6	5.5	5.0	7.9	10.0	18.9	16.2	17.5	8.5	4.3	4.4	4.2	4.5
7	5.5	5.0	8.1	11.0	20.9	16.1	17.3	8.3	4.2	4.4	4.2	4.5
8	5.3	5.0	8.1	11.9	21.5	15.9	17.0	8.0	4.2	4.4	4.2	4.5
9	5.3	5.6	8.0	13.0	21.9	15.9	16.5	7.8	4.2	4.4	4.2	4.9
10	5.2	5.9	8.0	13.9	21.3	15.7	15.9	7.6	4.2	4.4	4.1	5.0
11	5.2	6.0	8.4	14.3	20.7	15.5	15.5	7.4	4.5	4.4	4.1	5.0
12	5.1	6.1	8.5	14.5	20.0	15.1	15.1	7.2	4.5	4.3	4.1	5.0
13	5.2	6.5	8.5	14.4	19.9	14.9	14.8	6.9	4.6	4.2	4.1	5.0
14	5.2	6.5	8.5	14.0	19.4	15.0	14.5	6.7	4.6	4.1	4.1	5.1
15	5.2	6.7	8.4	14.2	18.9	14.9	14.2	6.5	4.7	4.0	4.3	5.2
16	5.1	6.4	8.3	14.0	18.7	14.8	13.8	6.3	4.7	4.0	4.3	5.2
17	5.0	6.3	8.3	13.5	18.6	14.4	13.4	6.1	4.7	4.0	4.3	5.1
18	5.0	6.1	8.0	13.6	18.5	14.4	13.0	5.9	4.7	4.0	4.3	5.0
19	*5.0	6.0	7.9	13.4	18.3	14.8	12.8	5.7	4.6	4.0	4.4	5.0
20	*5.0	6.0	7.8	13.1	18.5	15.0	12.5	5.6	4.6	4.0	4.4	5.3
21	*5.0	6.0	7.7	13.0	18.8	15.2	12.2	5.3	4.5	4.0	4.4	5.3
22	*4.9	6.0	7.5	12.9	19.0	15.6	12.1	5.1	4.5	4.0	4.4	5.2
23	*4.9	6.0	7.3	12.8	19.0	15.6	11.9	5.0	4.4	4.0	4.8	5.2
24	*4.9	6.0	7.1	12.6	18.7	15.9	11.6	4.8	4.4	4.0	4.8	5.2
25	*4.9	6.3	7.1	12.5	18.4	16.5	11.3	4.8	4.4	4.0	4.8	5.1
26	*4.8	6.5	7.0	12.3	18.1	17.5	11.1	4.7	4.4	4.0	4.8	5.1
27	*4.8	6.9	7.1	12.0	17.9	18.4	10.9	4.7	4.4	4.0	4.8	5.0
28	*4.8	7.0	7.5	11.9	17.5	18.5	10.6	4.5	4.4	4.0	4.8	4.9
29	*4.8	7.1	7.8	11.8	17.4	18.4	10.3	4.4	4.4	4.0	4.6	4.9
30	*4.7	......	7.9	11.5	17.3	17.9	10.2	4.4	4.4	4.0	4.6	4.7
31	*4.7	......	7.9	......	17.0	......	10.0	4.4	......	4.0	......	4.7
Averages	5.1	5.8	7.8	12.1	17.8	16.0	13.9	6.5	4.4	4.1	4.3	4.9
1893.												
1	4.6	4.3	13.2	15.2	15.7	11.6	7.9	3.6	3.0	3.5	3.9	4.0
2	4.6	4.3	13.3	14.9	15.7	11.6	7.8	3.6	3.0	3.6	3.9	4.0
3	4.5	4.6	13.7	14.6	15.7	11.6	7.5	3.6	3.0	3.6	3.9	4.0
4	4.5	4.6	13.9	14.6	15.8	11.4	7.3	3.6	3.0	3.8	3.8	4.0
5	4.5	4.6	15.0	14.0	16.2	11.2	7.0	3.6	3.0	3.9	3.8	4.0
6	4.5	4.6	15.4	14.0	16.5	11.2	6.7	3.6	3.0	3.9	3.8	4.0
7	4.5	4.6	15.6	13.7	16.4	11.4	6.3	3.6	3.0	3.9	3.8	4.0
8	4.5	5.0	15.8	13.3	16.4	11.7	6.0	3.6	3.0	4.0	3.9	4.0
9	4.5	5.0	16.0	12.6	16.0	11.6	5.8	3.6	3.0	4.0	3.9	4.0
10	4.5	5.0	17.5	12.4	15.8	11.6	5.7	3.6	3.0	3.9	3.9	4.1
11	4.5	4.8	18.4	12.0	15.6	11.4	5.7	3.6	3.0	4.0	3.9	4.1
12	4.5	5.6	19.6	12.0	15.0	11.2	5.6	3.5	3.0	4.0	3.9	4.1
13	4.2	6.5	19.6	12.0	14.7	11.2	5.5	3.5	3.2	4.0	3.9	4.1
14	4.2	6.8	19.2	11.9	14.9	11.2	5.3	3.4	3.2	4.0	3.9	4.1
15	4.2	8.0	18.9	11.8	14.7	11.1	5.1	3.3	3.2	4.0	3.9	4.1
16	4.2	9.8	18.6	12.0	15.0	11.1	4.9	3.3	3.2	4.0	3.9	4.0
17	4.2	10.3	18.2	12.0	15.4	11.1	4.7	3.2	3.2	4.0	3.9	4.4
18	4.2	11.0	17.6	11.6	15.2	10.9	4.5	3.2	3.2	4.0	3.9	4.4
19	4.2	12.4	17.0	11.8	15.1	10.8	4.5	3.2	3.2	4.0	3.9	4.5
20	4.2	12.8	16.5	11.8	14.9	10.6	4.5	3.2	3.2	3.9	3.9	4.6
21	4.2	13.1	16.2	11.9	14.3	10.3	4.4	3.2	3.2	3.9	3.9	4.8
22	4.2	13.4	15.8	12.0	14.0	10.0	4.4	3.2	3.2	3.9	3.9	5.0
23	4.2	13.6	15.7	12.5	13.8	9.8	4.2	3.0	3.2	3.9	3.9	5.0
24	4.1	13.8	15.5	14.3	13.7	9.0	4.2	3.0	3.5	3.9	3.9	5.0
25	4.1	13.4	15.4	14.8	13.4	9.0	4.0	3.0	3.6	3.9	4.0	5.0
26	4.1	13.3	15.6	15.4	12.9	8.9	3.9	3.0	3.6	3.9	4.0	5.0
27	4.1	13.2	15.6	15.4	12.9	8.9	3.8	3.0	3.6	3.9	4.0	4.9
28	4.1	13.1	15.4	15.4	12.3	8.8	3.7	3.0	3.4	3.9	4.1	4.8
29	4.7	......	15.4	15.5	12.3	8.8	3.7	3.0	3.4	3.9	4.1	4.8
30	4.7	......	15.4	15.5	12.1	8.3	3.6	3.0	3.4	3.9	4.0	4.8
31	4.7	.....	15.3	......	11.9	......	3.6	3.0	......	3.9	......	4.9
Averages	4.3	8.9	16.2	13.3	14.6	10.5	5.2	3.3	3.1	3.9	3.8	4.4

***Interpolated quantities.**

Gauge Readings for Illinois River—Continued.

	Jan.	Feb.	Mar.	April	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1894.												
1	4.9	5.8	6.0	9.0	7.5	7.2	4.3	3.4	3.2	4.9	3.8	4.3
2	4.9	5.8	6.0	8.9	7.4	7.0	4.3	3.4	3.2	4.9	3.8	4.3
3	5.3	5.9	6.0	8.8	7.0	6.8	4.3	3.4	3.2	4.9	3.8	4.3
4	5.4	5.5	6.0	8.5	6.9	6.6	4.3	3.5	3.2	4.7	4.0	4.3
5	5.4	5.5	6.0	8.5	6.8	6.4	4.3	3.5	3.2	4.5	4.0	4.3
6	5.4	5.5	6.1	8.4	6 9	6.2	4.3	3.5	3.4	4.5	4.3	4.3
7	5.3	5.4	8.2	8.3	6.9	6.2	4.3	3.5	3.6	4.5	4.3	4.3
8	5.3	5.4	8.8	8.1	7.4	6.3	4.2	3.5	4.0	4.5	4.3	4.3
9	5.2	5.5	9.9	8.1	8.3	6.2	4.2	3.3	4.4	4.3	4.3	4.3
10	5.2	5.5	10.0	8.1	8.6	5.8	4.2	3.3	4.7	4.2	4.3	4.3
11	5.2	5.6	11.4	7.8	9.0	5.6	3.9	3.1	5.2	4.0	4.3	4.3
12	5.2	5.6	11.7	7.5	9.0	5.4	3.9	3.1	5.7	4.0	4.3	4.3
13	5.2	5.6	11.9	7.4	9.1	5.2	3.7	3.1	6.0	3.9	4.3	4.3
14	5.0	5.6	12.3	7.4	9.1	5.2	3.6	3.1	6.2	3.8	4.3	4.5
15	5.0	5.5	12.0	7.4	9.2	5.0	3.6	3.1	6.2	3.8	4.3	4.5
16	5.0	5.5	12.0	7.4	9.2	4.8	3.6	3.1	6.4	3.8	4.3	4.5
17	4.9	5.7	12.0	7.4	9.2	4.6	3.6	3.1	6.4	3.8	4.3	4 5
18	4.9	6.0	12.0	7.7	8.8	4.6	3.6	3.1	6.4	3.8	4.3	5.0
19	4.9	6.2	12.0	7.9	8.7	4.6	3.6	3.1	6.4	3.8	4.3	5.1
20	4.9	6.3	11.8	7.7	8.7	4.6	3.6	3.4	6.3	3.8	4.3	5.1
21	5.4	6.3	11.6	7.7	8.6	4.6	3.5	3.4	6.3	3.8	4.3	5.1
22	5.6	6.1	11.0	7.7	8.2	4.6	3.5	3.4	6.1	3.8	4.3	5.1
23	5.5	6.1	10.8	7.7	8.2	4.6	3.5	3.4	6.1	3.8	4.3	5.1
24	5.5	6.1	10.8	7.7	8.1	4.5	3.5	3.4	5.8	3.8	4.3	5.1
25	5.7	6.0	10.8	7.7	8.0	4.5	3.4	3.3	5.7	3.8	4.3	5.0
26	5.7	6.0	10.8	7.7	8.0	4.5	3.4	3.3	5.5	3.8	4.3	5.0
27	5.9	6.0	10.4	7.7	7.8	4.5	3.4	3.3	5.3	3.8	4.3	4.9
28	5.6	6.0	10.0	7.6	7.8	4.4	3.4	3.3	5.1	3.8	4.3	4.8
29	5.6	......	9.7	7.6	7.7	4.4	3.4	3.3	5.1	3.8	4.3	4.7
30	5.6	......	9.6	7.5	7.6	4.4	3.4	3.2	4.9	3.8	4.3	4.7
31	5.6	......	9.5	......	7.4	......	3.4	3.2	......	3.8	......	4.7
Averages	5.2	5.7	9.9	7.8	8.1	5.3	3.7	3.2	5.1	4.0	4.2	4.6
1895.												
1	4.1	4.9	7.2	5.8	5.0	3.9	3.8	5.3	3.8	4.1	3.7	4.5
2	4.1	4.8	7.5	6.0	4.9	3.9	3.8	5.0	3.7	4.0	3.7	4.6
3	4.0	4.6	7.7	6.0	4.8	3.9	3.8	4.7	3.6	3.9	3.7	4.6
4	4.0	4.5	7.7	5.8	4.7	3.9	3.8	4.7	4.4	3.8	3.7	4.6
5	4.0	4.4	8.0	5.7	4.6	3.8	3.7	4.6	5.3	3.8	3.8	4.6
6	3.9	4.2	7.9	5.7	4.6	3.8	3.7	4.4	5.5	3.7	3.8	4.6
7	3.8	4.1	7.9	5.9	4.6	3.8	3.6	4.3	5.5	3.7	4.0	4.6
8	3.6	4.0	7.8	6.1	4.6	3.7	3.9	4.0	4.9	3.7	4.2	4.5
9	3.6	3.9	7.6	6.1	4.6	3.7	4.2	3.9	4.8	3.7	4.4	4.5
10	3.5	3.8	7.6	6.2	4.6	3.6	4.0	3.8	4.7	3.7	4.4	4.5
11	3.5	3.8	7.5	6.5	4.6	3.6	3.9	3.8	4.6	3.9	4.3	4.5
12	3.4	3.8	7.4	6.9	4.6	3.5	3.9	3.7	4.4	4.0	4.1	4.5
13	3.3	3.7	7.3	7.1	4.6	3.5	3.8	3.6	4.2	3.8	4.0	4.5
14	3.3	3.7	7.3	7.3	4.6	3.4	3.7	3.7	4.1	3.7	4.0	4.5
15	3.3	3.6	7.1	7.3	4.5	3.4	3.8	3.7	4.0	3.7	4.1	4.4
16	3.3	3.5	7.0	7.3	4.5	3.4	3.9	3.7	3.9	3.7	4.2	4.3
17	3.3	3.5	6.8	7.3	4.5	3.3	4.3	3.7	4.2	3.7	4.2	4.3
18	3.3	3.5	6.8	7.3	4.5	3.3	4.6	3.7	4.3	3.7	4.4	4.6
19	3.3	3.5	6.7	7.1	4.5	3.2	4.9	3.7	4.3	3.6	4.5	5.6
20	3.3	3.5	6.6	6.9	4.5	3.2	5.6	3.6	4.2	3.6	4.6	7.6
21	3.3	3.5	6.5	6.8	4.5	3.1	6.0	3.6	4.2	3.6	4.4	8 9
22	3.3	3.5	6.3	6.7	4.5	3.1	6.3	3.5	4.1	3.7	4.5	10.5
23	3.3	3.6	6.1	6.5	4.5	3.1	6.0	3.4	4.1	3.7	4.5	12.0
24	3.3	3.7	6.1	6.2	4.4	3.1	5.7	3.5	4.0	3.7	4.4	13.3
25	3.3	5.1	6.1	6.0	4.4	3.1	5.6	3.5	3.9	3.7	4.4	14.3
26	3.3	5.7	6.1	5.9	4.3	3.5	5.2	3.7	4.3	3.7	4.4	14.6
27	3.5	6.2	6.1	5.8	4.1	3.7	5.6	3.7	4.7	3.7	4.3	14.5
28	4.0	6.7	6.1	5.6	3.9	3.8	5.7	3.7	4.5	3.7	4.3	14.7
29	4.2	......	5.9	5.3	3.9	3.8	5.7	3.7	4.3	3.7	4.4	14.9
30	4.4	......	5.8	5.2	3.9	3.8	5.6	3.8	4.3	3.7	4.4	14.7
31	4.7	......	5.8	......	3.9	......	5.6	3.9	......	3.7	......	14.6
Averages	3.6	4.2	6.9	6.3	4.4	3.5	4.6	3.9	4.3	3.7	4.1	7.7

Gauge Readings For Illinois River—Continued.

1896	Jan.	Feb.	Mar.	April	May	June	July	Aug	Sep.	Oct.	Nov.	Dec.
1	14.3	8.8	11.5	8.4	7.8	10.0	5.6	9.5	6.6	5.8	5.9	7.4
2	13.8	8.9	11.8	8.3	7.7	9.8	5.5	9.7	6.5	6.6	5.8	7.3
3	13.4	9.0	11.9	8.3	7.6	9.5	5.4	9.5	6.4	7.6	5.9	7.2
4	13.3	9.1	11.9	8.2	7.4	9.4	5.4	9.3	6.4	7.8	6.1	7.1
5	13.1	9.2	11.6	8.1	7.3	9.2	5.4	9.3	6.4	8.3	6.2	7.0
6	12.8	9.5	11.5	8.0	7.2	8.9	5.1	8.9	5.9	8.7	6.3	6.9
7	12.6	9.8	11.2	7.9	7.2	8.6	4.7	8.9	5.8	8.8	6.3	7.3
8	12.3	10.0	11.0	7.7	6.8	8.4	4.5	8.9	5.5	8.9	6.4	7.2
9	12.1	10.2	10.9	7.6	6.5	8.4	4.5	8.5	5.4	8.9	6.5	7.0
10	11.8	10.1	10.9	7.5	6.3	8.2	4.3	8.5	5.5	8.7	6.6	6.9
11	11.6	10.0	10.8	7.4	6.1	7.8	4.3	8.4	5.5	8.7	6.8	6.8
12	11.4	9.9	10.8	7 3	5.9	7.8	4.0	8.4	5.5	8.6	7.1	6.9
13	11.2	9.9	10.7	7.3	5.8	7.5	3.9	8.0	5.5	8.4	7.5	6.8
14	10.9	9.9	10.5	7.0	5.5	7.8	3.8	7.8	5.5	8.1	7.7	7.0
15	10.8	9.5	10.6	6 8	5.5	7.8	3.7	7.6	5.5	7.9	7.7	6.8
16	10.7	9.0	10.3	6.7	5.4	7.7	3.6	7.7	5.5	7.8	7.8	6.7
17	10.3	8.8	10.0	7.0	5.3	7.7	3.6	7.6	5.8	7.6	8.0	6.6
18	9.9	8.4	9.8	6.8	5.4	7.4	3.6	7.6	5.9	7.5	7.9	6.6
19	9.6	8.3	9.7	6.7	6.0	7.4	3.6	7.6	5.9	7.3	8.1	6.5
20	9.2	8.3	9.6	6.6	6.5	7.3	4.2	7.6	6.0	7.0	8.0	6.6
21	8.9	8.1	9.4	6.6	7.0	7.0	4.5	7.7	6.2	6.9	7.8	6.4
22	8.6	7.8	9.3	6.6	7.7	6.7	4.5	7.6	6.3	6.7	7.7	6.3
23	8.5	7.7	9.2	6.6	8.3	6.5	4.6	7.4	6.0	6.7	7.5	6.2
24	8.3	8.2	9.2	6.6	8.6	6.4	4.8	7.3	5.8	6.6	7.5	6.0
25	8.2	8.9	8.8	7.0	8.5	6.2	5.6	7.2	5.7	6.4	7.5	5.8
26	8.2	9.5	8.8	7.6	8.7	6.2	5.9	7.2	5.7	6.4	7.3	5.7
27	8.3	10.0	8.7	7.9	9.2	6.0	6.8	7.1	5.7	6.3	7.5	5.5
28	8.4	10.6	8.6	8.0	9.8	5.9	7.8	7.0	5.7	6.2	7.6	5.4
29	8.5	11.1	8.5	8.0	10.0	5.8	8.6	6.9	5.6	6.1	7.6	5.5
30	8.5	......	8.4	7.9	10.1	5.8	9.2	6.7	5.7	5.9	7.6	5.5
31	8.7	......	8.3	......	10.2	......	9.2	6.7	......	5.8	......	5.4
Averages	10.5	9.2	10.1	7.4	7.3	7.6	5.1	8.0	5.8	7.3	7.1	6.5

1897	Jan.	Feb.	Mar.	April	May	June	July	Aug	Sep.	Oct.	Nov.	Dec.
1	5.4	12.4	13.2	17.3	11.5	6.7	9.1	4.7	3.9	3.7	3.8	4.9
2	5.6	12.1	13.0	17.0	11.3	6.3	8.9	4.6	3.9	3.7	3.8	4.4
3	6.4	12.1	12.8	16.8	11.2	6.2	8.6	4.5	3.9	3.7	3.8	4.3
4	7.6	12.0	12.7	16.3	11.2	6.0	8.2	4.4	3.9	3.7	3.8	4.2
5	10.0	11.8	12.6	16.0	11.0	5.9	8.0	4.3	3.9	3.7	3.8	4.2
6	11.7	11.7	12.6	15.8	10.9	5.9	7.9	4.3	3.9	3.7	3.9	4.3
7	13.2	11.5	12.7	15.5	10.9	5.8	8.0	4.2	3.9	3.7	3.9	4.3
8	14.3	11.4	12.8	15.0	10.8	5.7	7.9	4.1	3.9	3.7	4.0	4.3
9	14.8	11.3	13.1	14.9	10.5	5.6	7.6	4.1	3.9	3.7	4.1	4.3
10	14.9	11.1	13.3	14.5	10.3	5.5	7.3	4.0	3.9	3.7	4.1	4.3
11	14.9	11.0	14.0	14.2	10.0	5.4	7.1	4.0	3.9	3.7	4.1	4.3
12	14.7	10.9	14.4	13.9	10.0	5.3	6.8	4.0	3.9	3.7	4.1	4.3
13	14.5	10.8	15.0	13.5	9.8	5.3	6.4	3.9	3.9	3.7	4.2	4.3
14	14.4	10 8	15.6	13.5	9.6	5.0	6.1	3.9	3.9	3.7	4.2	4.3
15	14.1	10.7	16.0	13.3	9.5	4.8	5.9	3.8	3.9	3.7	4.2	4.2
16	13.9	10.7	16.2	13.0	9.4	4.6	5.8	3.8	3.9	3.8	4.3	4.4
17	13.7	10.6	16.1	12.9	9.2	4.5	5.8	3.9	3.9	3.8	4.3	4.2
18	13.6	10.8	16.2	12.5	9.3	4.8	5.7	3.8	3.9	3.8	4.3	4.2
19	13.8	11.0	16.3	12.5	9.0	5.4	5.7	3.8	3.9	3.7	5.3	4.2
20	14.0	11.2	16.7	12.3	8.7	5.8	5.8	3.8	3.9	3.7	4.3	4.4
21	14.2	11.5	17.0	12.0	8.4	6.5	5.7	3.8	3.9	3.8	4.3	4.2
22	14.2	11.9	17.8	11.5	8.1	6.9	5.8	3.8	3.9	3.8	4.3	4.2
23	14.1	12.6	18.2	11.6	7.9	7.4	5.9	3.8	3.9	3.8	4.4	4.2
24	13.5	13.3	18.3	11.6	7.8	7.9	5.9	3.7	3.9	3.8	4.3	4.2
25	13.5	13.7	18.3	11.5	7.5	8.8	5.9	3.7	3.9	3.8	4.6	4.2
26	13.4	13.8	18.3	11.3	7.4	9.3	5.7	3.8	3.8	3.8	4.8	4.1
27	13.2	13.6	18.3	11.3	7.3	9.5	5.5	3.8	3.8	3.8	4.9	4.1
28	13.0	13.4	18.2	11.2	7.2	9.6	5.3	3.8	3.8	3.8	4.8	4.1
29	12.8	......	18.0	11.4	7.1	9.5	5.1	3.8	3.7	3.8	4.7	4.1
30	12.6	......	17.7	11.4	7.0	9.4	4.9	3.9	3.7	3.8	4.7	4.1
31	12.5	......	17.5	......	6.8	......	4.9	3.9	......	3.8	......	4.1
Averages	12.3	11.7	15.5	13 5	9.2	6.5	6.5	4.0	3.8	3.7	4.2	4.2

Gauge Readings for Illinois River—Continued.

	Jan.	Feb.	Mar.	April	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1898.												
1	4.1	7.8	12.5	19.2	10.8	13.5	9.1	4.1	4.6	5.3	7.8	8.4
2	4.1	7.9	12.5	19.0	10.6	13.3	8.9	4.1	4.5	5.1	7.8	8.3
3	4.1	7.8	12.5	18.7	10.5	13.1	8.8	4.1	4.5	5.1	7.7	8.2
4	4.0	7.7	12.3	18.3	10.3	12.8	8.6	4.2	4.4	5.0	7.6	8.1
5	4.0	7.6	12.1	18.0	10.2	12.5	8.4	4.0	4.4	5.0	7.4	8.0
6	4.0	7.4	12.0	17.3	10.0	12.1	7.9	4.2	5.0	5.0	7.3	7.7
7	4.0	7.2	11.8	16.8	9.8	11.8	7.5	4.3	5.4	5.0	7.3	7.5
8	4.0	7.0	11.7	16.3	9.7	11.5	7.3	4.4	5.5	4.9	7.2	7.4
9	4.0	6.9	11.6	15.9	9.6	11.2	7.3	4.3	5.6	4.9	7.3	7.1
10	4.0	6.9	11.9	15.4	9.5	11.2	6.7	4.3	5.6	4.8	7.2	7.2
11	4.0	7.5	12.2	15.1	9.4	11.1	6.3	4.3	5.6	4.9	7.2	7.2
12	4.3	8.4	13.0	14.8	9.3	11.1	5.9	4.3	5.3	4.9	7.3	7.1
13	4.8	9.2	13.7	14.4	9.0	11.0	5.6	4.2	5.3	4.9	7.6	7.1
14	5.0	10.0	14.3	14.3	8.9	11.1	5.3	4.1	5.3	4.9	8.4	7.0
15	5.2	10.7	14.8	14.0	8.8	11.2	5.0	4.1	5.5	4.9	9.0	6.9
16	5.3	11.4	15.2	13.8	9.0	11.0	4.7	4.2	5.4	4.7	9.4	6.8
17	5.2	11.9	15.5	13.5	9.2	11.0	4.3	5.3	5.4	4.7	9.7	6.3
18	5.1	12.3	15.6	13.3	9.4	10.8	4.0	5.6	5.3	4.8	9.9	6.1
19	5.1	12.6	15.7	13.1	9.7	10.6	3.9	5.6	5.3	5.0	9.9	6.0
20	5.4	12.8	16.0	12.9	10.6	10.3	3.9	5.6	5.3	5.1	9.9	5.9
21	5.8	13.0	16.8	12.6	11.8	10.0	3.9	5.6	5.1	5.2	9.9	5.9
22	6.3	13.1	17.1	12.3	12.5	9.7	3.9	5.7	5.0	5.3	9.7	6.0
23	6.8	13.4	17.4	12.3	13.0	9.5	3.8	5.5	5.0	5.4	10.0	6.3
24	7.0	13.4	17.3	12.1	13.6	9.3	3.5	5.4	5.6	5.4	9.9	6.3
25	7.2	13.1	17.2	11.8	14.0	9.1	3.7	5.4	5.8	5.7	9.7	6.6
26	7.3	13.8	17.0	11.7	14.0	8.8	3.6	5.3	5.8	6.5	9.4	6.8
27	7.4	13.7	17.2	11.5	14.1	8.9	3.6	5.2	5.7	6.8	9.1	6.8
28	7.5	13.2	17.6	11.2	14.0	9.1	3.8	5.0	5.6	7.1	8.8	6.8
29	7.5	......	18.3	11.1	14.0	9.1	4.1	4.9	5.5	7.6	8.6	6.9
30	7.6	......	19.0	10.9	14.0	9.1	4.1	4.8	5.4	7.8	8.5	7.0
31	7.7	......	19.3	......	13.8	......	4.1	4.7	......	8.0	......	7.2
Averages	5.4	10.2	14.8	14.4	11.1	10.8	5.5	4.7	5.2	5.5	8.5	7.0
1899.												
1	7.5	8.3	11.4	13.0	8.7	7.5	3.9	4.3	3.7	4.0	4.6	4.7
2	7.7	8.1	12.2	13.0	8.5	7.7	3.8	4.4	3.7	4.0	4.6	4.6
3	7.8	8.0	12.9	13.0	8.3	8.1	3.8	4.3	3.7	4.0	4.5	4.7
4	7.8	7.8	13.7	12.8	8.0	8.2	4.0	4.3	3.8	4.0	4.4	4.7
5	7.9	7.6	14.2	12.6	7.9	8.4	4.2	4.3	3.7	4.0	4.5	4.5
6	8.2	7.4	14.5	12.6	7.7	8.5	4.3	4.3	3.8	4.0	4.5	4.6
7	8.3	7.2	14.5	12.5	7.5	8.5	4.4	4.2	3.8	4.0	4.5	4.5
8	8.5	7.0	14.5	12.5	7.4	8.5	4.6	4.0	4.0	4.0	4.5	4.5
9	8.7	6.8	14.3	12.5	7.2	8.4	4.5	3.9	3.9	4.0	4.6	4.5
10	8.9	6.8	14.2	12.4	7.0	8.2	4.5	3.9	3.9	4.0	4.6	4.6
11	9.0	6.7	14.1	12.2	6.8	8.7	4.5	4.0	3.9	4.0	4.7	4.7
12	8.9	6.7	13.9	12.0	6.8	7.0	4.5	4.0	3.9	4.2	4.7	4.8
13	8.8	6.6	14.1	12.0	6.8	7.4	4.5	3.9	3.9	4.2	4.7	5.1
14	8.8	6.2	14.2	11.9	6.7	7.2	4.5	3.8	3.9	4.2	4.8	5.2
15	8.6	5.9	14.2	11.8	6.7	7.2	4.4	3.7	3.8	4.3	4.8	5.2
16	8.5	5.8	14.2	11.8	6.7	7.0	4.9	3.7	3.8	4.2	4.9	5.3
17	8.6	5.6	14.2	11.5	7.0	6.7	5.5	3.6	3.9	4.4	4.8	5.4
18	8.7	5.4	14.3	11.3	7.4	6.4	5.8	3.6	4.3	4.3	5.0	5.4
19	9.0	5.3	14.4	11.2	7.7	6.3	6.0	3.5	4.3	4.3	5.1	5.5
20	9.1	5.3	14.8	11.0	7.9	6.1	6.2	3.5	4.2	4.3	5.0	5.6
21	9.2	5.3	15.0	10.9	8.0	6.0	6.2	3.5	4.2	4.2	5.0	5.7
22	9.3	5.9	15.1	10.8	8.1	5.7	6.1	3.4	4.1	4.2	5.0	5.9
23	9.3	6.0	14.9	10.5	8.0	5.4	5.9	3.4	4.2	4.3	5.0	6.1
24	9.2	6.3	14.8	10.3	7.8	5.3	5.7	3.4	4.2	4.3	5.0	6.3
25	9.0	6.8	14.5	10.0	7.7	5.1	5.5	3.5	4.2	4.3	4.9	6.2
26	9.0	8.5	14.4	9.9	7.5	4.9	5.3	3.5	4.1	4.3	4.8	6.5
27	9.0	9.9	14.3	9.6	7.3	4.7	5.1	3.4	4.1	4.5	4.8	6.5
28	8.9	10.6	14.1	9.4	7.3	4.5	4.9	3.4	4.1	4.6	4.7	6.4
29	8.8	......	13.8	9.3	7.2	4.4	4.7	3.4	3.9	4.5	4.7	6.2
30	8.7	......	13.8	9.0	7.2	4.1	4.6	3.5	3.9	4.5	4.8	6.0
31	8.6	......	13.7	......	7.3	......	4.4	3.6	......	4.5	......	6.8
Averages	8.6	6.9	14.1	11.4	7.4	6.7	4.8	3.7	3.9	4.2	4.7	5.3

Gauge Readings for Illinois River—Continued.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1900												
1	5.6	7.7	12.3	15.8	11.5	8.6	7.3	7.3	8.0	6.4	6.7	9.6
2	5.5	7.8	12.2	16.3	11.3	8.7	7.2	7.3	8.1	6.3	6.8	9.7
3	5.4	7.8	12.0	16.7	11.1	8.7	7.2	7.4	8.2	6.5	6.8	9.7
4	5.4	7.9	11.8	16.9	10.8	8.8	7.2	7.3	8.2	6.5	6.7	9.6
5	5.3	7.7	11.6	16.9	10.5	8.9	7.1	7.3	8.1	6.7	6.7	9.6
6	5.1	7.6	11.5	16.7	10.3	8.8	7.0	7.3	8.0	6.8	6.7	9.5
7	5.0	7.5	11.4	16.4	10.1	8 8	6.9	7.0	7.9	6.9	6.7	9.5
8	5.0	8.3	11.3	16.1	10.0	8.8	7.0	7.0	7.7	6.9	6.8	9.4
9	4.9	9.3	11.4	15.8	10.1	8.8	6.9	6.9	7.4	6.9	6.8	9.3
10	5.0	10.0	11.8	15.6	9.9	8.6	6.9	6.8	7.2	6.9	6.7	9.2
11	5.0	10.5	12.5	15.3	9.8	8.6	6.7	6.7	6.8	6.7	6.9	9.1
12	5.1	11.0	13.8	14.8	9.7	8.5	6.6	6.7	6.8	6.7	6.8	8.9
13	5.2	11.3	15.4	14.5	9.7	8.4	6.5	6.7	6.7	7.0	7.0	8.9
14	5.2	11.5	17.4	14.2	9.6	8.3	6.4	6.8	6.5	6.6	7.0	8.8
15	5.1	11.5	19.2	14.0	9.6	8.1	6.4	7.0	6.3	6.4	7.1	8.7
16	5.1	11.4	19.9	13.8	9.5	7.8	6.3	7.9	6.0	6.5	6.9	8.5
17	5.1	11.4	19.9	13.6	9.4	7.6	6.4	8.1	6.2	6.4	6.9	8.4
18	5.7	11.5	19.5	13.3	9.3	7.4	6.4	8.1	6.2	6.3	6.9	8.4
19	6.1	11.5	19.0	13.3	9.4	7.3	6.4	8.0	6.3	6.4	7.0	8.4
20	6.6	11.4	18.7	13.3	9.3	7.3	6.4	7.9	6.3	6.3	7.2	8.4
21	7.1	11.4	18.3	13.3	9.1	7.2	6.5	7.9	6.0	6.2	7.2	8.4
22	7.5	11.5	17.8	13.2	8.9	7.1	6.5	7.9	5.8	6.4	7.6	8.3
23	7.7	11.6	17.6	13.1	8.8	7.0	6.5	7.8	5.6	6.4	7.9	8.1
24	7.8	11.6	17.4	13.0	8.7	6.8	6.4	7.7	5.4	6.6	8.1	8.4
25	8.1	12.0	17.0	12.8	8.7	6.9	6.6	7.7	5.3	6.6	8.6	8.4
26	8.1	12.3	16.7	12.6	8.7	7.1	6.6	7.7	5.4	6.6	9.0	8.3
27	8.1	12 3	16.4	12.5	8.6	7.2	6.6	7.7	5.8	6.6	9.2	8.1
28	7.9	12.4	16.1	12.3	8.6	7.3	6.6	7.7	6.0	6.5	9.4	8.1
29	8.0	......	16.0	12.0	8.7	7.4	6.7	7.7	6.0	6.6	9.5	8.0
30	7.9	......	15.8	11.9	8.7	7.4	6.9	7.8	6.4	6.7	9.5	8.0
31	7.7	......	15.7	......	8.7	......	7.1	8.0	......	6.7	......	8.0
Averages	6.14	10.34	15.40	14.33	9.60	7.94	6.72	7.46	6.68	6.58	7.20	8.76

Resumé of Gauge Readings of Illinois River at Bridge Street Bridge, Peoria, Illinois.

(Average Gauge, Date and Duration of Maximum and Minimum Gauges.)

	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899
January.										
Maximum—										
Date	20	8-10	4	29-31	27	31	1	10-11	31	28
Gauge	12.3	4.9	5.8	4.7	5.9	4.7	14.3	14.9	7.7	9.3
Minimum—										
Date	1,2	1,2	30,31	24-28	(g)	13-26	25	1	4	1
Gauge	6.2	3.8	4.7	4.1	4.9	3.3	8.2	5.4	4.0	7.5
Average gauge	9.5	4.3	5.1	4.3	5.2	3.6	10.5	12.3	5.4	8.6
February.										
Maximum—										
Date	1	28	29	24	20,21	28	29	26	24	28
Gauge	9.0	8.6	7.1	13.8	6.3	6.7	11.1	13.8	12.4	10.6
Minimum—										
Date	10	2,3	1-3	1,2	7,8	16-23	21	17	10	19
Gauge	7.7	3.9	4.7	4.3	5.4	3.5	8.1	10.6	6.9	5.3
Average gauge	8.2	4.7	5.8	8.9	5.7	4.1	9.2	11.7	10.1	6.9
March.										
Maximum—										
Date	16,31	31	12-14	12,13	15-19	5	3,4	24-27	31	22
Gauge	10.0	10.0	8.5	19.6	12.0	8.0	11.9	18.3	19.3	15.1
Minimum—										
Date	9,10	12	26	1	1-5	30	31	5	9	1
Gauge	6.7	6.7	7.0	13.2	6.0	5.8	8.3	12.6	11.6	11.4
Average gauge	7.6	8.3	7.8	16.2	9.9	6.9	10.1	15.5	14.8	14.1
April.										
Maximum—										
Date	21	17-19	12	29,30	1	14-18	1	1	1	1
Gauge	13.8	15.0	14.5	15.5	9.0	7.3	8.4	17.3	19.2	13.0
Minimum—										
Date	2,30	1	1	18	13-17	30	20-24	28	30	30
Gauge	10.6	10.3	8.1	11.6	7.4	5.2	6.6	11.2	10.9	9.0
Average gauge	12.0	13.1	12.1	13.3	7.8	6.3	7.4	13.5	14.3	11.4
May.										
Maximum—										
Date	31	1	9	6	15-17	1	31	1	27	1
Gauge	11.7	12.8	21.9	16.5	9.2	5.0	10.2	11.5	14.1	8.7
Minimum—										
Date	10-13	31	2	31	5	28-31	17	31	15	14
Gauge	8.8	4.9	10.9	11.9	6.8	3.9	5.3	6.8	8.8	6.7
Average gauge	10.0	8.5	17.8	14.6	8.1	4.4	7.3	9.2	11.0	7.1
June.										
Maximum—										
Date	26	24,25	28	8	1	1-4	1	28	1	11
Gauge	13.3	8.9	18.5	11.7	7.2	3.9	10.0	9.6	13.5	8.7
Minimum—										
Date	14	(b)	17,18	30	28-30	21-25	29	17	26	30
Gauge	8.9	4.8	14.4	8.3	4.4	3.1	5.8	4.5	8.8	4.1
Average gauge	11.2	6.7	16.0	10.5	5.3	3.5	7.6	6.5	10.8	6.7

Resumé of Gauge Readings of Illinois River—Concluded.

	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899
July.										
Maximum—										
Date	1	1	1-6	1	1-7	22	30, 31	1	1	20
Gauge	11.6	7.1	17.5	7.9	4.3	6.3	9.2	9.1	9.1	6.2
Minimum—										
Date	28-31	(c)	31	30, 31	25-31	5	16-19	31	24	2
Gauge	3.0	3.3	10.0	3.6	3.4	3.7	3.6	4.9	3.5	3.8
Average gauge	6.9	4.6	13.9	5.2	3.7	4.6	5.1	6.5	5.5	4.8
August.										
Maximum—										
Date	22-31	18, 19	1	1-11	4-8	1	2	1	22	2
Gauge	3.3	3.9	9.9	3.6	3.5	5.3	9.7	4.7	5.7	4.4
Minimum—										
Date	1-20	6-10	29-31	23-31	11-10	23	30	......	5	27
Gauge	3.0	3.1	4.4	3.0	3.1	3.4	6.7	3.8	4.0	3.4
Average gauge	3.1	3.4	6.5	3.3	3.2	3.9	8.0	3.9	4.7	3.7
September.										
Maximum—										
Date	19-21	6, 7	15-18	25-27	16-19	6, 7	1	......	......	19
Gauge	3.6	3.4	4.7	3.6	6.4	5.5	6.6	3.9	5.8	4.3
Minimum—										
Date	2-7	(d)	7-10	1-12	1, 5	3	9	......	......	1
Gauge	3.2	3.0	4.2	3.0	3.2	3.6	5.4	3.7	4.4	3.7
Average gauge	3.4	3.1	4.4	3.1	5.1	4.3	5.8	3.8	5.2	3.9
October.										
Maximum—										
Date	20	1-7	1-11	(e)	1-3	1	9	......	30	28
Gauge	4.9	3.0	4.4	4.0	4.9	4.1	8.9	3.8	8.0	4.6
Minimum—										
Date	7-12	16-21	15-31	1	14-31	19	1-31	......	16	1
Gauge	2.6	2.7	4.0	3.5	3.8	3.6	5.8	3.7	4.7	4.0
Average gauge	3.5	2.8	4.1	3.9	4.0	3.7	7.3	3.7	5.4	4.2
November.										
Maximum—										
Date	(a)	28-30	23-28	28, 29	6-30	20	19	......	23	19
Gauge	4.6	5.0	4.8	4.1	4.3	4.6	8.1	4.9	10.0	5.1
Minimum—										
Date	4, 5	1	1-3	4-7	1-3	1	2	......	10	4
Gauge	3.6	2.9	4.0	3.8	3.8	3.7	5.8	3.8	7.2	4.4
Average gauge	4.1	3.8	4.3	3.9	4.2	4.1	7.1	4.2	8.5	4.7
December.										
Maximum—										
Date	1-4	24-26	20-21	22-26	19-24	29	1	......	......	31
Gauge	4.4	5.9	5.3	5.0	5.1	14.9	7.4	4.4	8.4	6.8
Minimum—										
Date	25-30	4	1-8	(f)	1-13	16	28	......	......	5
Gauge	3.8	4.7	4.5	4.0	4.3	4.3	5.4	4.1	5.9	4.5
Average gauge	4.0	5.4	4.9	4.4	4.6	7.7	6.5	4.2	6.7	5.3
Average for year	6.9	5.7	8.5	7.6	5.5	4.7	7.7	7.8	8.5	6.8

(a) 23 and 27-29.
(b) 2 and 4-7.
(c) 28, 29 and 31.
(d) 11-14, 17 and 19-30.
(e) 8, 9 and 11-19.
(f) 1-9 and 16
(g) 1, 2 and 17-20.

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THE DISCHARGE OF THE ILLINOIS RIVER AND ITS PRINCIPAL TRIBUTARIES.

Preparatory to making comparative tables of rainfall upon and run-off from the Illinois basin, the gaugings of the tributaries and the Illinois at Peoria heretofore given in this report were instituted. Sufficient velocity gaugings were made at Peoria to determine the flow at that point with a fair degree of accuracy. Taking as the abscissas, the discharges as computed from the velocity and measured cross-section, and as ordinates, the stages of the river at the Bridge Street Bridge and drawing a curve through the points thus platted, a curve of discharge was constructed from which the discharge data has been taken. The daily stage of the Illinois at the Bridge Street Bridge has been kept by the U. S. Weather Bureau for many years and with these stages the daily discharge in cubit feet per second can be read directly from these curves or the subsequent table of discharge by stages of feet and tenths for any known stage of the river.

In order to get an evenly balanced curve where the points are some distance apart the discharges and stages were platted on logarithmic paper giving a straight line. From this logarithmic diagram or "curve" the discharge for each foot in depth was taken and the natural curve of discharge was platted, which shows the relation of discharge to stage of river on a natural scale. It should be remembered that the gauge from which the stages are read were set at low water before the Copperas creek dam was closed and that about a 3-foot stage since that time (1877) is really equivalent to original low water mark of the Illinois river at Peoria.

Table of Discharges in Cubic Feet Per Second at Peoria, Ill., for Stages of Two to Twenty-two Feet, by Tenths on Gauge at Bridge Street Bridge.

Stage—Feet.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1	65	....	....	....	....	....	....	....	....	....
2	399	446	496	549	604	662	723	786	852	921
3	992	1,066	1,142	1,221	1,303	1,387	1,474	1,564	1,657	1,752
4	1,850	1,950	2,054	2,160	2,268	2,380	2,494	2,612	2,732	2,854
5	2,980	3,108	3,239	3,372	3,509	3,648	3,790	3,935	4,082	4,233
6	4,390	4,546	4,706	4.868	5,034	5,202	5,373	5,548	5,725	5,906
7	6,089	6,275	6,464	6,656	6,851	7,049	7,251	7,455	7,663	7,874
8	8,087	8,303	8,523	8,745	8,971	9,201	9,433	9,669	9,907	10,150
9	10,395	10,643	10,894	11,149	11,407	11,668	11,933	12,201	12,471	12,746
10	13,025	13,307	13,592	13,880	14,172	14,467	14,765	15,066	15,371	15,678
11	15,989	16,303	16,621	16,941	17,265	17,592	17,923	18,256	18,593	18,934
12	19,277	19,625	19,976	20,329	20,686	21,046	21.408	21,773	22,140	22,511
13	22.889	23,268	23,649	24,034	24,421	24,810	25,203	25,598	25,996	26,397
14	26,800	27,206	27,615	28,027	28,441	28,858	29,278	29,701	30,126	30,554
15	30,985	31,417	31,852	32,290	32,731	33,175	33,623	34,073	34,527	34,984
16	35,444	35,900	36,360	36,825	37,296	37,771	38,250	38,734	39,222	39,717
17	40,217	40,714	41,215	41,720	42,230	42,745	43,264	43,788	43,316	44,848
18	45,384	45,925	46,470	47,019	47,572	48,130	48,693	49,259	49,830	50,406
19	50,985	51,576	52,169	52,766	53,365	53,967	54,570	55,177	55,788	56,401
20	57,020	57,653	58,285	58,918	59,550	60,182	60,814	61,445	62,077	62,708
21	63,339	63,977	64,615	65,250	65,891	66,523	67,154	67,775	68,404	69,031
22	69,655	....	....	....	....	....	....	....	....	....

The foregoing table has been taken from curve platted to average the discharge measurements, which have been taken at Peoria, and the table carefully balanced throughout so as to eliminate irregularities of readings. All of the discharges for the Illinois river are based on this table, and the mean monthly discharges were obtained by taking the average of the daily discharges as determined by the daily gauge readings. The mean monthly discharges do not, therefore, correspond to the discharge for mean gauge reading for such month, but are the actual average discharges therefor.

The following tables show for each month (1) the maximum and minimum stage of the Illinois river at the Bridge Street Bridge, Peoria, Illinois; (2) the discharge in cubic feet per second corresponding to those stages; (3) the mean monthly discharge in cubic feet per second; (4) depth in inches flowing off each monfh aod year, and (5) the average discharge in cubic feet per second per square mile for each month and year.

These tables have been prepared from tne preceding table of discharges which was taken from the discharge curve. It will be observed that the highest stages and greatest monthly run off usually occur between February and June, and the latter part of the year the run off is always low. Abundant summer and fall rains tend to maintain a stage of 4 to 5 feet and a discharge of 1,800 to 3,000 cubic feet per second, which is from 3 to 5 times the amount of sewage from the Illinois and Michigan canal, but in periods of little summer rainfall, as in autumn of 1891, the average flow for an entire month has been below 1,000 cubic feet per second.

Illinois River Discharges at Peoria, Illinois.

(Drainage area 13,480 square miles.)

Month.	Discharge in Second-feet.					Run Off.	
	Maximum.		Minimum.		Mean.	Depth Inches	Second Feet Sq. Mi.
	Gauge.	Disch.	Gauge.	Disch.			
1890							
January	12.3	20,329	6.2	4,706	12,201	1.025	.905
February	9.0	10,395	7.7	7,455	8,523	.712	.632
March	10.0	13,025	6.7	5,548	9,551	.802	.709
April	13.8	25,996	10.6	14,765	19,395	1.628	1.440
May	11.7	18,256	8.8	9,907	13,025	1.093	.966
June	13.3	24,034	8.9	10,150	17,103	1.436	1.268
July	11.6	17,923	3.0	992	6,950	.583	.515
August	3.3	1,221	3.0	992	1,066	.089	.078
September	3.6	1,474	3.2	1,221	1,303	.109	.096
October	4.9	2,854	2.6	723	1,800	.151	.133
November	4.6	2,494	3.6	1,474	1,950	.159	.144
December	4.4	2,268	3.8	1,657	1,850	.155	.136
Year	13.8	25,996	2.6	723	7,893	7.942	.588
1891							
January	4.9	2,854	3.8	1,657	2,193	.185	.162
February	8.6	9,433	3.9	1,752	2,793	.235	.206
March	10.0	13,025	6.7	5,548	8,808	.739	.653
April	15.0	30,985	10.3	13,880	22,649	1.903	1.682
May	12.8	22,140	4.9	2,854	9,988	.839	.741
June	8.9	10,150	4.8	2,732	5,906	.496	.437
July	7.1	6,275	3.3	1,221	2,612	.218	.194
August	3.9	1,752	3.1	1,066	1,286	.108	.094
September	3.4	1,303	3.0	992	1,055	.088	.077
October	3.0	992	2.7	786	892	.076	.067
November	5.0	2,980	2.9	921	1,737	.146	.128
December	5.9	4,233	4.7	2,612	3,549	.298	.262
Year	15.0	30,985	2.7	786	5,289	5.331	.392
1892							
January	5.8	4,080	4.7	2,612	3,108	.260	.229
February	7.1	6,275	4.7	2,612	4,335	.364	.321
March	8.5	9,201	7.0	6,089	7,763	.652	.575
April	14.5	28,858	8.1	8,303	20,517	1.722	1.521
May	21.9	69,031	10.9	15,678	46,342	3.889	3.440
June	18.5	48,130	14.4	28,441	35,977	3.020	2.672
July	17.5	42,745	10.0	13,025	27,615	2.318	2.032
August	9.9	12,746	4.4	2,268	5,725	.481	.425
September	4.7	2,612	4.2	2,054	2,302	.193	.170
October	4.4	2,268	4.0	1,850	1,980	.165	.147
November	4.8	2,732	4.0	1,850	2,202	.185	.165
December	5.3	3,372	4.5	2,380	2,885	.241	.212
Year	21.9	69,031	4.0	1,850	13,396	13.490	.994
1893							
January	4.7	2,612	4.1	1,950	2,214	.186	.164
February	13.8	25,996	4.3	2,160	11,721	.984	.869
March	19.6	54,570	13.2	23,649	37,296	3.132	2.768
April	15.5	33,175	11.6	17,923	24,571	2.064	1.823
May	16.5	37,771	11.9	18,934	29,068	2.440	2.176
June	11.7	18,256	8.3	8,745	14,914	1.254	1.107
July	7.9	7,874	3.6	1,474	3,464	.291	.275
August	3.6	1,474	3.0	992	1,362	.115	.101
September	3.6	1,474	3.0	992	1,156	.107	.084
October	4.0	1,850	3.5	1,387	1,752	.147	.129
November	4.1	1,950	3.8	1,657	1,765	.148	.130
December	5.0	2,980	4.0	1,850	2,272	.191	.168
Year	19.6	54,570	3.0	992	10,966	11.060	.815

Illinois River Discharges at Peoria, Illinois—Continued.

Month.	Discharge in Second-Feet.					Run Off.	
	Maximum.		Minimum.		Mean.	Depth, Inches	Sec.-Ft Sq. Mi.
	Gauge.	Disch.	Gauge.	Disch.			
1894.							
January	5.9	4,233	4.9	2,854	3,372	.288	.256
February	6.3	4.868	5.4	3,509	4,107	.344	.301
March	12.0	19,277	6.0	4,390	13,592	1.141	1.008
April	9.0	10,395	7.4	6,851	7,905	.664	.586
May	9.2	10,894	6.8	5,725	8,413	.706	.624
June	7.2	6,464	4.4	2,268	3,481	.293	.258
July	4.3	2,160	3.4	1.303	1,657	.139	.122
August	3.5	1,387	3.1	1,066	1,208	.101	.088
September	6.4	5,034	3.2	1,142	3,283	.275	.242
October	4.9	2,854	3.8	1,657	1,825	.153	.135
November	4.3	2,160	3.8	1,657	2,059	.173	.152
December	5.1	3,108	4.3	2,160	2,495	.210	.185
Year	12.0	19,277	3.1	1.066	4,460	4.487	.331
1895.							
January	4.7	2,612	3.3	1,221	1,502	.126	.111
February	6.7	5,548	3.5	1,387	2,160	.182	.160
March	8.0	8,087	5.8	4,082	5,998	.504	.445
April	7.3	6,656	5.2	3,239	5,008	.420	.371
May	5.0	2,980	3.9	1.752	2,437	.205	.181
June	3.9	1,752	3.1	1.066	1,387	.116	.102
July	6.3	4,868	3.7	1,564	2,624	.220	.194
August	5.3	3,372	3.4	1,303	1,834	.153	.134
September	5.5	3,648	3.6	1,474	2,450	.206	.181
October	4.1	1,950	3.6	1,387	1,590	.135	.115
November	4.6	2,494	3.7	1,564	2,059	.172	.151
December	14.9	30,554	4.3	2,160	11,022	.925	.817
Year	14.9	30,554	3.1	1.066	3,338	3.364	.247
1896.							
January	14.3	28,027	8.2	8,523	15,555	1.306	1.153
February	11.1	16,303	8.1	8,303	11,257	.945	.834
March	11.9	18,934	8.3	8,745	13,767	1.156	1.020
April	8.4	8,971	6.6	5,373	6,999	.588	.519
May	10.2	13,592	5.3	3,372	7,124	.598	.526
June	10.0	13,025	5.8	4,082	7,585	.636	.561
July	9.2	10,894	3.6	1,474	3,524	.296	.261
August	9.7	12,201	6.7	5,548	8,390	.705	.624
September	6.6	5,373	5.4	3,509	4,148	.349	.308
October	8.9	10,150	5.8	4,082	7,029	.590	.521
November	8.1	8,303	5.8	4,082	6,464	.543	.480
December	7.4	6,851	5.4	3,509	5,350	.449	.396
Year	14.3	28,027	3.6	1,474	8,099	8.161	.600
1897.							
January	14.9	30,554	5.4	3,509	22,786	1.912	1.689
February	13.8	25,996	10.6	14,765	18,738	1.574	1.390
March	18.3	47,019	12.6	21,408	34,527	2.900	2.560
April	17.3	4,720	11.2	16,621	25,231	2.119	1.852
May	11.5	17.592	6.8	5,725	12,540	1.053	.930
June	9.6	11,933	4.5	2,380	5.666	.475	.419
July	9.1	10,643	4.9	2,854	5,607	.473	.417
August	4.7	2,612	3.8	1,657	1,852	.155	.136
September	3.9	1,752	3.7	1,564	1,734	.146	.128
October	3.8	1,657	3.7	1,564	1,549	.128	.113
November	4.9	2,854	3.8	1,657	2,115	.177	.156
December	4.4	2,268	4.1	1,950	1,734	.146	.128
Year	18.3	47,019	3.7	1,564	11,173	11.258	.826

Illinois River Discharges at Peoria, Illinois—Continued.

Month.	Discharge in Second—Feet.					Run Off.	
	Maximum.		Minimum.		Mean.	Depth. Inches	Sec.-ft. Sq. Mi.
	Gauge.	Disch.	Gauge.	Disch.			
1898.							
January	7.7	7,455	4.0	1,850	3,845	.322	.285
February	13.4	24,421	6.9	5,906	15,180	1.275	1.126
March	19 3	52,766	11.6	17,923	31,643	2.658	2.346
April	19.2	52,169	10.9	15,678	29,468	2.476	2.186
May	14.1	27,206	8.8	9,907	17,275	1.451	1.281
June	13.5	24,810	8.8	9,907	15,935	1.339	1.182
July	9.1	10,643	3.5	1,387	4,259	.357	.315
August	5.7	3,935	4.0	1,850	2,678	.225	.198
September	5.8	4,082	4.4	2,268	3,372	.283	.249
October	8.0	8,087	4.7	2,612	3,762	.315	.278
November	10.0	13,025	7.2	6,464	9,559	.800	.707
December	8.4	8,971	5.9	4,233	6,102	.512	.451
Year	19.3	52,766	3.5	1,387	11,923	12.013	.884
1899.							
January	9.3	11,149	7.5	7,049	9,641	.809	.715
February	10.6	14,765	5.3	3,372	6,264	.526	.464
March	15.1	31,417	11.4	17,265	27,308	2.294	2.026
April	13.0	22,889	9.0	10,395	17,730	1.490	1.318
May	8.7	9,669	6.7	5,548	7,100	.596	.526
June	8.7	9,669	4.1	1,950	5,954	.500	.442
July	6.2	4,706	3.8	1,657	2,888	.241	.212
August	4.4	2,268	3.4	1,303	1,678	.141	.124
September	4.3	2,160	3.7	1,564	1,813	.153	.134
October	4.6	2,494	4.0	1,850	2,054	.172	.152
November	5.1	3,108	4.4	2,268	2,660	.224	.196
December	6.8	5,725	4.5	2,380	3,448	.290	.259
Year	15.1	31,417	3.4	1,303	7,378	7.436	.547
1900.							
January	8.1	8,303	4.9	2,874	4,924	.416	.365
February	12.4	20,686	7.5	7,049	14,500	1.218	1.076
March	19.9	56,401	11.3	16,941	35,100	2.948	2.604
April	16.9	39,717	11.9	18,934	29,110	2.444	2.160
May	11.5	17,592	8.6	9,433	12,036	1.011	.893
June	8.9	10,150	6.8	5,725	8,093	.677	.597
July	7.3	6,656	6.3	4,868	5,590	.470	.416
August	8.1	8,303	6.7	5,548	7,149	.601	.530
September	8 2	8,523	5.3	3,372	5,666	.476	.420
October	7.0	6,089	6.3	4,868	5,382	.452	.399
November	9.5	11,668	6.7	5,548	7,071	.594	.525
December	9.7	12,201	8.0	8,087	9,688	.814	.718
Year	19.9	56,401	4.9	2,874	12,026	12.121	.892

The following tables of average monthly rain-fall on the Illinois river basin above Peoria and average monthly run-off at that point and the annual summary showing run-off, rainfall, per cent of rain running off, cubic feet per second and second feet per square mile, show the relations existing between rain and run-off for the upper Illinois for 10 years, 1890 to 1899, inclusive. The run-off as given includes the Chicago sewage which flows through the Illinois and Michigan canal from Bridgeport, where it is pumped in from the south branch of the Chicago river:

Average Monthly Rainfall on Illinois River Basin above Peoria and Average Monthly Run-off at Peoria, Illinois.

Month.	1890.		1891.		1892.		1893.		1894.		1895.		1896.		1897.		1898.		1899.	
	Off.	On.	Off.	On.	Off.	On.	Off.	On.	Off.	On.	Off.	On.	Off.	On.	Off.	On.	Off	On.	Off.	On.
January	1.025	3.01	.185	2.23	.260	1.40	.186	1.80	.288	2.10	.126	1.43	1.306	1.02	1.912	5.59	.322	3.88	.809	1.57
February	.712	1.58	.235	2.23	.364	1.53	.984	2.26	.344	1.58	.182	.54	.945	1.95	1.674	1.75	1.275	2.44	.526	1.30
March	.802	2.78	.739	2.56	.652	2.21	3.132	2.51	1.141	2.77	.504	1.13	1.156	1.62	2.900	4.22	2.658	5.46	2.294	2.99
April	1.628	3.09	1.903	3.89	1.722	4.35	2.064	5.41	.664	2.77	.420	1 96	.588	3.48	2.119	3.14	2.476	1.84	1.490	1.11
May	1.093	4.66	.839	2.17	3.889	9.63	2.440	2.78	.706	3.46	.205	2.46	.598	5.26	1.053	1.39	1.451	4.76	.596	5.93
June	1.436	6.61	.496	4.16	3.020	9.18	1.254	3.12	.293	2.26	.116	1.74	.636	3.07	.475	4.52	1.339	5.04	.500	2.39
July	.583	.93	.218	2.80	2.318	3.42	.291	1.78	.139	.61	.220	4.04	.296	5.57	.473	3.18	.357	1.51	.241	4.34
August	.089	2.54	.108	4.08	.481	1.86	.115	.36	.101	1.23	.153	3.50	.705	2.87	.155	1.99	.225	4.28	.141	2.27
September	.109	1.75	.088	.87	.193	1.97	.107	2.90	.275	7.61	.206	2.28	.349	7.42	.146	.97	.283	4.07	.153	2.99
October	.151	4.41	.076	.94	.234	.79	.147	1.51	.153	1.35	.135	.84	.590	.54	.128	.42	.315	4.30	.172	2.75
November	.159	1.69	.146	4.22	.185	2.36	.148	2.41	.173	1.90	.172	3.76	.543	2.86	.177	3.86	.800	2.43	.224	1.77
December	.185	.74	.298	2.15	.241	1.84	.191	1.96	.210	1.08	.925	5.63	.449	.37	.146	1.60	.512	1.48	.290	1.70
Annual	7.97	33.79	5.33	32.30	13.56	40.54	11.06	28.80	4.49	28.72	3.36	29.81	8.16	36.03	11.34	32.63	12.01	41.49	7.44	31.11

Illinois River Basin Above Peoria.

Area, 13,480 square miles. Rainfall and run-off. Annual summary.

Year.	Run off. Inches.	Rainfall. Inches.	Per Cent Running Off.	Cubic Feet per Second.	Second Feet per Square Mile.
1890	7.942	33.79	23.6	7,893	.588
1891	5.331	32.30	16.5	5,289	.392
1892	13.555	40.54	33.4	13,396	.994
1893	11.060	28.80	38.4	10,966	.815
1894	4.487	28.72	15.6	4,460	.331
1895	3.364	29.81	11.3	3,338	.247
1896	8.161	36.03	22.6	8,099	.600
1897	11.258	32.63	34.5	11,173	.826
1898	12.013	41.49	29.0	11,923	.884
1899	7.436	31.11	23.9	7,378	.547
Averages	8.460	33.52	25.2	8,391	.622
Without flow from I. & M. Canal	7.860	33.52	23.4	7.791	.576

NOTE.—The flow from Illinois and Michigan Canal to Des Plaines River is estimated at 600 cubic feet per second for ten years prior to 1900, which is equivalent to .6 inches of run-off per year, or .0445 second feet per square mile from entire territory above Peoria.

The period under discussion has been one of low rainfall, the average for the ten years having been 33.52 inches, while the normal rainfall for Illinois as given by Leverett in "Water Resources of Illinois," is 37.85 inches, an average annual shortage of 4.33 inches. During that time the rainfall exceeded the normal only two years, viz: 1892 and 1898, the intervening years being regarded as the greatest period of severe drought that has been experienced in this region since it has been settled.

By referring to the annual summary table which shows the annual rainfall, run-off and percentage of rain running off, the erratic conditions prevailing are very clearly brought out; for example: By comparing the years 1891 and 1893; in the former year the rainfall was 32.3 inches and run-off 5.33 inches, or 16.5 per cent. In the latter year the rainfall was 28.8 inches, being 3.5 inches less, the run-off was 11.06, being 5.73 inches more run-off than in 1891, or 38.4 per cent of the entire rainfall of the year. For an explanation of this condition in run-off for those two years, the greater run-off having occurred with the less rainfall, an examination of the table of monthly run-off and rainfall is necessary.

In 1891 the run-off for January, February, March and April, the months when the ground is usually frozen or saturated with water from the spring rains, was 3.06 inches, for a rainfall during the same months of 10.91 inches, showing a very porous condition of the earth, following a very low rainfall from July, 1900 to the end of that year. In contrast with this, in 1893, during the months of February, March, April and May, the run-off was 8.62 inches with a rainfall of 13.16 inches. During the latter part of 1892 the rainfall was even less than during the latter part of 1890, showing very clearly that the aggregate amount of run-off during any year is dependent very largely upon the condition of the ground during the first four or five months of the year.

In 1892 the rainfall was above the normal, being 40.54 inches; 26.58 inches of this rain fell during the months of April, May, June and July, causing the largest floods in the Illinois river which have occurred for perhaps forty years. The run-off during these months was 10.95 inches while for the entire year the run-off was 13.56 inches. Again comparing the heavy run-off of the early part of 1892 with that of 1893, we find that in 1892 over 26 inches of rain fell in four months ending with July, 42.5 per cent running off, owing largely to the saturated condition of the earth, while in 1893, with a rainfall of 13.16 inches in four months ending with May, the run-off was 8.62 inches or 65.5 per cent, this greater percentage of run-off being due to the greater imperviousness of the earth and further to less evaporation because of lower temperature and lack of vegetation.

A casual inspection of the table of monthly rainfall and run-off indicates very clearly that with rare exceptions the greater part, approximately three-quarters of the run-off, occurs during the first six months in the year, January and February also generally being months of low flow. During the latter part of the year, from July to January, exceptionally heavy rainfalls have occurred without materially affecting the run-off, for example: In October, 1890, 4.41 inches of rain fell with 0.15 inches of run-off, and in November, 1891, 4.22 inches of rain fell with 0.15 inches of run-off. In November, 1892, 2.36 inches of rain fell with 0.18 inches of run-off. In September, 1893, 2.90 inches of rain fell with 0.11 inches of run-off. In September, 1894, 7.61 inches of rain fell with 0.27 inches of run-off. In this case a rainfall of practically 5.5 inches above the normal only produced a run-off of about 0.1 inch more than occurred during the years of about normal rainfall for this month. In September, 1896, there was a rainfall of 7.42 inches which had been preceded by a rainfall of 2.87 inches and 5.57 inches in August and July respectively, with a run-off of 0.35 inches. This was the largest run-off for the month of September during the entire period of the ten years, occasioned by the heavy rains which were practically continuous from April to near the end of September.

These instances of heavy rainfall and heavy run-off are sufficient to illustrate the conditions which will produce the greatest run-off.

Again referring to the table of annual rainfall and run-off, it will be seen that the range in percentage of rainfall which has actually run off at Peoria is 11.3 per cent in 1895 with a rainfall of 29.81, and a run-off of 38.4 per cent in 1893 with 28.8 inches of rainfall, the run-off in inches being 3.36 inches in 1895 and 11.06 inches in 1893, the rainfall being nearly equal for these years.

Referring again to the table of monthly rainfall and run-off, it will be seen as before stated, that in 1893 a heavy run-off occurred with a heavy rainfall in the early part of the year when the ground was frozen and later when it was saturated with water from the heavy rains. In 1895 on the contrary, the rains from January to April inclusive, only amounted to 5.06 inches with a correspondingly low run-off, while heavy rains beginning with May and continuing through the remainder of the year, except October, were almost en-

tirely absorbed in consequence of the extreme drought of the latter six months of the three years preceding, the total run-off for the year 1895 being 3.36, the lowest for any year during the period.

The average run-off is 8.46 inches with an average rainfall of 33.52 inches which is 25.2 per cent.

All of this data includes the flow from the Illinois and Michigan canal, which is equivalent to .6 of an inch per annum over the entire basin of the Illinois above Peoria. If this be deducted the run-off would amount to 7.86 inches or 23.4 per cent. It will be seen that while the average run-off for the upper Illinois basin does not vary materially from other streams in this latitude, that the variation in run-off from year to year and from month to month is very great. From the lowest to the highest in the table given, the lowest in 1895, 3.36, and the highest in 1892, 13.55, the range in run-off is over 400 per cent. The actual low water flow at Peoria during the last ten years has for days and sometimes weeks been as low as 1,000 to 1,200 cubic feet per second, approximately 600 cubic feet of which, has been furnished through the Illinois and Michigan canal by the pumps at Bridgeport; this quantity being sewage from the south branch of the Chicago river, and often being more than half and occasionally as much as three-quarters of the entire flow at Peoria. The effect of a flow through the new drainage channel of 5,000 cubic feet per second or more can very easily be imagined from the foregoing data when we understand that the natural flow of the Illinois river at Peoria has apparently been as low as 200 to 300 cubic feet per second.

The flow of the Illinois river at Peoria is made up of the combined flow of the tributaries above, including the sewage from Chicago which reaches the DesPlaines river at Joliet by way of the Illinois river and Michigan canal. The DesPlaines river at Riverside, a few miles above Joliet, goes entirely dry at that point nearly every fall and for days and weeks at a time there is no appreciable flow. On the Dupage river, which enters the DesPlaines a few miles above the junction of the DesPlaines and the Kankakee, no data as to the low water flow is at hand, except the discharge measurement taken under my direction in October, 1899, which shows 32.77 cubic feet per second. This flow is greater than that found in the DesPlaines on the previous day. The flow in the DesPlaines at Riverside was 13.21 cubic feet per second. The waters of the Dupage are added to the DesPlaines before they reach the Illinois, so that the natural flow in the DesPlaines, where it joins the Kankakee to form the Illinois, at the time of the gaugings referred to were taken would have been approximately 50 cubic feet per second, while the amount of sewage flowing through the Illinois and Michigan canal was 600 cubic feet per second. Practically all of the flow of the DesPlaines river, as it reaches the Illinois, is, therefore, during dry weather, Chicago sewage.

Detail observations of the flow of the DesPlaines river at Riverside have been taken more or less continuously since 1887. The area of the drainage basin above this point is 630 square miles. The

estimated monthly discharge of the river has been published in the 20th annual report of the geological survey for the years 1886 to 1898, inclusive. The data is not complete for several of the intervening years, but for such years as complete data is at hand the run-off, the rainfall, the percentage of rainfall running off and the discharge in second feet per square mile are given in the following table:

Des Plaines River Basin Above Riverside.

Rainfall Running "Off" and actually Falling "On".

Year.	Off. Inches.	On. Inches.	Per Cent of Rain Running Off.	Second Feet Per Square Mile.
1887	13.18	29.13	45.2	1.00
1889	6.13	34.95	17.6	0.45
1893	10.38	29.03	35.8	0.76
1894	7.44	27.80	26.8	0.55
1895	3.08	30.48	10.1	0.23
1896	5.04	33.74	15.0	0.38
1897	14.05	30.55	46.0	1.03
1898	10.92	37.74	29.0	0.81
Averages	8.777	31.68	27.7	0.65

It will be observed that the range in run-off is from 3.08 inches with a rain-fall of 30.48 inches for the year 1895, to a run-off of 14.05 inches with a rain-fall of 30.55 in 1897. From a water shed which is recognized as a comparatively impervous area, this range is accounted for by the fact of very low rain-fall in 1893 and 1894, preceding the small run-off in 1895. The high run-off of 1887, 1893, 1897 and 1898 is due in each case to winter freshets. An examination of the details of the tables of run-off shows 8.12 inches of run-off against an exactly equal amount of rainfall in the first three months, January, February and March, 1887, and 5.47 inches of run-off to 6.21 inches of rainfall in the corresponding months of 1893. In 1897 and 1898 the run-off for the same three months was 11.24 inches and 7.88 inches, respectively. In 1895 when the very low run-off of 3.08 inches occurred, the run-off for the first three months of the year was only .92 of an inch, It is also noted that in 1895, with a rainfall of 30.48 inches and a run-off of 3.08 inches, and in 1897 with a rainfall of only .07 of an inch more for the whole year, or 30.55 inches, the run-off was 14.05 inches Again in 1898 with a rainfall of 30.74 inches the run-off was 10.92 inches. During the summer months one of the highest rainfalls recorded was 9.56 inches, in July 1889, and produced a run-off of only 1.09 inches. Another record of excessive summer rainfall (the record for the year not being complete) was in May and June, 1892; the rainfall in May was 6.77 inches and in June 10.58 inches, the run-off being 4.58 inches and 6.06 inches respectively. The winter, spring and early summer storms are therefore capable of producing heavy freshets, and consequently large run-offs from the DesPlaines water shed; but heavy rains do not produce a corresponding run-off if occurring during the summer or fall. From this it is evident that the condition of the surface of the basin, as affected by temperature, being impervious

when frozen and covered with snow, is the greatest factor in producing a large run-off. Whenever the rainfall may be slight during the spring and early summer months, there will be a correspondingly small run-off for the year.

The following table shows the run-off from the DesPlaines river at Riverside and the Illinois river at Peoria for the years 1893 to 1898, inclusive.

Comparison of Run Off.

Illinois River Basin Above Peoria. Des Plaines River Basin Above Riverside.

YEAR.	DEPTH IN INCHES.			SECOND FEET PER SQUARE MILE.		
	Des Plaines.	Illinois.	Illinois Less Canal	Des Plaines.	Illinois.	Illinois Less Canal
1893	10.38	11.06	10.46	0.76	.815	.769
1894	7.44	4.49	3.89	0.55	.331	.285
1895	3.08	3.36	2.76	0.23	.247	.201
1896	5.04	8.16	7.56	0.38	.600	.554
1897	14.05	11.26	10.66	1.03	.826	.780
1898	10.92	12.01	11.41	0.81	.884	.838
Averages.	8.48	8.39	7.79	0.63	.617	.571

The average run-off from the Des Plaines river basin is 8.48 inches and from the Illinois river basin 8.39 inches. There is some variation in the depth of run-off and second feet per square mile, but some general relation exists. In 1897 and 1898 there is, however, quite a divergence which is worthy of note. In 1897 the run-off from the Des Plaines basin was 14.05 inches, and from the Illinois basin 11.26 inches. In 1898 the run-off from the Des Plaines was 10.92 and from the Illinois 12.01. In order to understand why the run-off from the Des Plaines should be more in 1897 and less in 1898 than from the Illinois, we are compelled to compare the rainfall with the run-off by months. In January, 1897, with an average rainfall upon the upper Illinois of 5.59 inches,there was a run-off at Peoria of 1.91 inches. On the contrary, an average rainfall of 5.37 inches on the DesPlaines was accompanied by a run-off of 5.26 inches. During the succeeding months of the same year the run-off and rainfall are nearly proportional, so that the excessive run-off for the one month of January places the run-off for the year abnormally high for the Des Plaines. The difference in run-off for the year 1898 is not so easily discovered. There was a large run-off from the Illinois at Peoria for each of the months February, March, April, May and June, the largest being in March 2.66 inches. On the Des Plaines basin over half of the run-off for the entire year was during the same month, being 5.83 inches. These very considerable differences in run-off per month do not make so great a difference in the actual run-off per year, but go to show the wonderful equalizing tendency of the larger area of the Illinois together with its great storage capacity in the wide valley from Utica to Peoria.

The drainage area of the Kankakee river is 5,146 square miles 3,640 of which lie in the State of Indiana and the remainder in Illinois. The general direction of the basin is east and west, with the extreme length 216 miles, and the greatest width from the north to south of about seventy miles. Although the area is not subdivided by well defined ridges, 2,000 square miles is drained by the Iroquois, the main tributary, and some 650 square miles by the Yellow river in Indiana, also a tributary from the south. The northern tributaries are in small water sheds of from 50 to 100 square miles, and are simply drains for the slope of the northern bounding ridge. Of the Iroquois water shed 828 miles are in Indiana. The area at Watseka, including Sugar Creek, is roughly 1,500 square miles or three-fourths of the total water shed. Below Watseka the principal tributaries to the Iroquois are Spring Creek, Beaver Creek and Longham's Creek, all heading in marshy areas which in recent years have been reclaimed and are now agricultural lands. At another place in this report is given the measured discharge of the Kankakee river at Lorenzo, Illinois, in October, 1899. The amount flowing at that time was 509 cubic feet per second. The river was very low, the observation having been taken at the end of a long rainless period, excepting that slight rains had occurred for two or three days just before the gaugings were taken and had raised the stage of the river about two inches.

The area of the water shed above Momence is 2,342 square miles, which is about 45 per cent of the total area of the Kankakee basin. About 650 square miles of this area is marsh which, until recently, was practically a shallow lake throughout the greater portion of the year. The mean flow of the Kankakee river at Momence was measured in 1871 by Father Stephen, a Catholic priest and civil engineer, who was in the employ of the Kankakee Drainage Co. The flow, as determined by him, was 1,271 cubic feet per second. This measurement was taken at the Indiana state line, and at Momence the same observer gave a flow of 1,457 cubic feet per second. These quantities were used for computing the capacity of ditches for draining the marshes. In 1893 Mr, Joseph L. Clark, civil engineer at Momence, made a measurement of the flow of the Kankakee river at Momence at a time when the water was very low and the volume of flow as ascertained by him was 407 cubic feet per second. Mr. Clark, who has been a resident of Momence for a great many years and interested in drainage problems of that vicinity, is of the opinion that the mean summer flow of the Kankakee river at Momence will not exceed 800 cubic feet per second and that it may be less. This estimate is based upon the conditions existing prior to 1899. During 1899 and 1900 very extensive drainage ditches have been constructed in the Kankakee valley above Momence and large areas of land reclaimed. These ditches have been cut about eight feet deep. The natural slope of the swamp is about one foot per mile from east to west, which is greater than is required for good drainage in the light soil of the region. During the summer of 1900 the flow has been greater than in former years, owing to the fact that the drainage has been deepened and the water is drawn from the lower region and by

seepage from a very extended territory so that the dredge ditches had given a continuous summer flow, whereas the slight channels existing prior to the construction of the ditches were formerly dry during the summer season.

The substratum of soil throughout this region is sandy and provides an immense reservoir from which the dredge ditches may draw. The marshy lakes have been regarded in the past as being the regulators of the regimen of the Kankakee river, and as such have received due credit for maintaining an equable flow. The first experience with the improved drainage, however, has, so far as low water conditions are affected, been contrary to the generally accepted theory that drainage of this region would increase the floods and decrease the summer or low water flow. Whether the increased flow which is now due to the draining out of the land and lowering of the ground water plain, when the plain shall have been lowered to its new position as affected by the new drainage, will diminish to the former flow or lower; or whether the large area and considerable depth of very porous soil acting as a reservoir, receiving and retaining the rainfall until it can flow by percolation and slower progress to the ditches, thus making a more equable and larger summer flow than has heretofore existed, are matters of some speculation, but in the opinion of the writer the latter condition is most probable. That is, the summer flow from the Kankakee will be permanently greater after complete drainage. Occasional floods, no doubt, will also be higher, but of very much shorter duration and only possible under conditions which would render the surface of the ground practically impervious to rainfall, as when covered with ice and snow or in case of prolonged excessive rains. The average summer flow during 1900 was about 1,400 cubic feet, as determined in a recent court proceeding regarding water rights upon the Kankakee at Wilmington. This amount is greater than any former estimates for average summer flow.

The DesPlaines and Kankakee which are the principal head water tributaries of the Illinois, constitute about one-half of the drainage area above Peoria, the only other tributaries of considerable importance being the Fox river from the north and the Vermilion river from the south. The total drainage area of the DesPlaines river is 1,322 square miles and the Kankakee 5,146 square miles. The Fox river 2,700 square miles and the Vermilion river 1,317 square miles. The total area of the Illinois drainage basin to Peoria is 13,479 square miles. No detailed information is at hand regarding the flow of the Fox and Vermilion rivers but it is known that in the summer time the Vermilion river goes dry and that the only flow coming from it is the sewage from the cities located upon its banks and the drainage from the mines.

The city of Streator takes its water supply from the Vermilion river, having constructed a dam some distance above the city. For a number of weeks during the summer no water passes this dam and the only flow in the river is the sewage of Streator, as was the case when discharge measurements were taken in October, 1899. At that time

the flow in the river above the impounding reservoir was .9 of a cubic foot per second; below Streator, approximately 4 cubic feet per second. The flow of the Fox river is more regular during the summer months than that of either the DesPlaines or Vermilion. The drainage basin is larger and contains a number of lakes which supply the river throughout the dry period. The flow as measured in October, 1899, above the dam, about eight miles from its mouth, was 321.95 cubic feet per second.

From the foregoing data it is quite evident that the contributions to the flow of the Illinois river during the dry periods come principally from the Kankakee river and the Fox river, the DesPlaines and the Vermilion being practically dry at these periods. The sewage from the city of Chicago, as we have found, being equal to or greater than the flow of all the tributary streams, some allowance, of course, to be made for losses by evaporation between the head waters of the Illinois and Peoria. There is, however, another source of supply for the Illinois river which has never been measured and is not taken into account. It is the numerous springs which abound in the valley throughout the course of the river from LaSalle to Beardstown. During periods of low water these springs have a very marked influence upon the quality and quantity of water flowing in the Illinois river, being the sub-drainage of the extensive valley and to a large extent the adjacent territory lying above the level of the river valley.

The following diagrams of monthly rainfall and run-off have been prepared to show at a glance the relation of rainfall to run-off and brings out in a very clear manner the monthly and annual variations in the actual as well as the relative amounts. The diagram of discharge in second feet per square mile also shows how the run-off varies from year to year and month to month.

These diagrams serve to accentuate the conclusions drawn from the foregoing table of rain-fall and run-off and show the drouth period of 1893-4-5 in the most unmistakable manner.

Table of Annual Discharge Data of Illinois River at Peoria.

Year.	Maximum cu. ft. per sec.	Minimum cu. ft. per sec.	Mean cu. ft. per sec.	Average for middle half cu. ft. per sec.	Ordinary cu. ft per sec.	Equivalent stage at Bridge St. Bridge.	Days below ordinary.
1890	25,996	723	7,893	6,554	4,438	6.0	165
1891	30,985	786	5,289	2,900	2,175	4.3	160
1892	69,031	1,850	13,396	6,784	4,612	6.1	184
1893	54,570	992	10,966	5,800	3,427	5.3	212
1894	19,277	1,066	4,460	3,222	2,599	4.7	159
1895	30,554	1,066	3,338	2,134	1,843	4.0	148
1896	28,027	1,474	8,099	7,257	6,040	7.0	137
1897	47,019	1,564	11,173	6,955	4,469	6.0	188
1898	52,766	1,387	11,923	8,294	6,043	7.0	148
1899	31,417	1,303	7,378	4,637	3,460	5.4	160
Average	38,964	1,221	8,391	5,454	3,911	5.7	166
1900	56,401	2,874	12,026	8,204	6,929	7.5	154

the flow in the river above the impounding reservoir

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the flow in the river above the impounding reservoir was 0.4

The foregoing table shows maximum, minimum, mean and ordinary discharge of the Illinois river at Peoria also the stages equivalent to ordinary flow and the number of days each year that the flow was less than the ordinary flow.

The ordinary flow has been computed with a view to getting an average flow for the year leaving out of that average the flood periods. The rule* applied is that proposed by Mr. Leslie as given in "Minutes of Proceedings of Institution of Civil Engineers," Vol. X, p. 327, and is as follows:

"Range the discharges as observed daily in their order of magnitude.

"Divide the list thus arranged into an upper quarter, and middle half, and a lower quarter.

"The discharges in the upper quarter of the list are to be considered as *floods*, and in the lower quarter as *minimum flows*.

"For each of the gaugings exceeding the average of the middle half, including flood gaugings, substitute the *average of the middle half of the list*, and take the mean of the whole list, and thus modified, for the *ordinary* or *average discharge, exclusive of flood waters*."

The table shows the maximum flood flow as 69,031 cubic feet per second in 1892 and the minimum flow as 723 cubic feet per second in 1890. During 1892 the lowest flow was 1,850 cubic feet per second. The low flows of 1890 and 1892 represent the range for the 10 years. The average minimum flow for 10 years 1,221 cubic feet per second. The ordinary flow ranged from 1,843 cubic feet per second in 1895 to 6,043 cubic feet per second in 1898, the average for the 10 years being 3,911 cubic feet or about three and one-fourth times the average extreme low water flow. The average of the mean annual flows is 8,391 cubic feet per second which is more than double the ordinary flow or nearly seven times the average minimum flow. Speaking generally, therefore, regarding the ordinary flow it may be said to have ranged from 2,500 to 4,000 cubic feet per second with occasional years above or below, prior to the change in the drainage of Chicago which became effective Jan. 17th, 1900. The ordinary flow for 1900 was about double the average for the precediug 10 year and higher than any year during that period. The extreme low water of 1900 was 2.3 times the average for the preceding 10 years, and 50 per cent. more than that of 1892. The average annual flow for 1900 was nearly 50 per cent. greater than the average for the preceding 10 years but not as great as for some of the years of heavy rainfall.

*See Fanning's Treatise on Hydraulic and Water Supply Engineering.

WATER SUPPLY AND SEWERAGE OF CITIES ON THE ILLINOIS RIVER BASIN.

Water Supply.

In order to get some definite information regarding public water supplies and sewerage systems letters were sent to the mayors of cities and presidents of villages of over 1,000 population asking for such information as is generally available and would be of interest in this investigation. One hundred and thirty-seven such were addressed; sixty-five replies were received, giving more or less detailed information. Twelve of those reporting have no water works systems. The following questions regarding water supply were asked:

QUESTIONS REGARDING WATER SUPPLY.

1. Water supply—public or private ownership?
2. How many miles of water mains?
3. What is the source of supply?
4. Is the supply subjected to contamination from any source, if so, give detailed description?
5. What method of purification, if any, is in use or contemplated?
6. How many water takers are there?
7. What is the daily average water consumption per year, also maximum and minimum daily consumption?
8. Is the water generally used for drinking and cooking, and if not, why not, and from what source or sources is the drinking water obtained?

The following statistical data has been compiled from the answers and from the Manual of American Water Works, 1897, where the data has not been supplied as requested. In the "remarks" column "no report" indicates no information at hand from any source and "not reported" indicates that no reply was received to inquiry, but the data given was procured from elsewhere.

Water Supply Statistics of Cities on Drainage Basin of Illinois River.

(P=Private. M=Municipal.)

City.	Miles of mains....	Water takers....	Per cent of population supplied..	Daily consumption 1,000 gallons.....	Ownership........	Source of Supply.	Remarks.
Abingdon							No report
Ashland							"
Assumption						Private wells	No system
Astoria							No report
Athens							"
Atlanta	* 5	200	79		M.	Drift well	Used for drink. Carries iron and not used for cooking
Auburn							No report
Augusta							"
Aurora	49	3,320	69	1,502	M.	Artesian well	General use
Averyville							
Batavia	17	921		133	M.	8-inch artesian well 1,300 feet deep	
Beardstown	* 5				M.		Not reported
Bement	2	70	24	30	M.	"Deep well"	General use
*Bloomington	27½	1,828	39	1,200	M.	Drift wells	General use; not reported
Braceville							No report
Bradley							"
Braidwood							"
Bushnell	5	100	20	10	M.	Artesian well 1,250 ft. deep and drift wells 100 ft	Drinking water from local drift wells
Camp Point							No report
Canton	8½	300	23	100	M.	Two artesian wells.	Used for drink
*Carbon Hill	1	7	3		M.	Artesian well 1,900 ft. deep	Not reported
*Carlinville	7	278	40	150	P.	Filtered; Macoupin creek	
*Carrollton	4½	132	28	100	M.	"Deep wells"	
*Carthage	2	75	18		M.	Artesian well 1,800 ft. deep	
Cerro Gordo							No report
Chatsworth							"
*Chenoa	5	41	14	25	M.	Wells 135 and 214 ft. deep	Not reported
Chicago	1,800				M.	Lake Michigan	"
*Chillicothe	4½	279	82	387	P.	Wells	"
*Clayton	⅔				P.	"	"
Clinton	* 8⅓	550	62	170	M.	Drift well 75 ft. deep	General use
*Coal City					M.		Fire protection only.
Colchester						Private wells	No system
Colfax							No report
Crotty							"
Cuba							"
Decatur	* 15	1,800	43	2,200	M.	Sangamon river mech. filters	General use
Delavan					M.	Springs	"
Downer's Grove	8	220	52	100	M.	2 10-inch deep wells	Not reported

Water Supply Statistics—Continued.

City.	Miles of mains....	Water takers.....	Per cent of population supplied..	Daily consumption 1,000 gallons.....	Ownership	Source of Supply.	Remarks.
Dundee...........	5	200	36	....	M.	Springs............	Pumped by water ram, and no record of amount kept....
Dwight	3	150	37	45	M.	Artesian wells	General use..........
*Earlville.........	¾	30	13	19	M.	10-in. artesian well.	Not reported.........
Edinburg.........	....	......	......	....	......	....	No report............
*Elgin	$39\frac{1}{4}$	2,408	54	1,000	M.	Fox river; filtered.	Not reported ....
*Elmhurst........	9	170	49	....	P.	Spring	" ....
*Elmwood	$3\frac{1}{4}$	65	21	15	M.	Artesian well.......	Not reported ....
El Paso...........	3	250	87	$1\frac{1}{2}$	......	Drift wells, 40 to 90 feet deep	General use..........
Eureka	*$\frac{3}{10}$	30	9	10	M.	Drift well	Not in general use. Drink from wells and cisterns.......
Fairbury	* 1	250	57	40	M.	Well	General use..........
Farmer City......	....	250	75	....	M.	Artesian well, 168 feet deep	" ....
Farmington	* 2	110	90	50	M.	Artesian well, 1.465 feet deep	" ....
Forrest	1	30	16	....	M.	Drift well...........	Private wells used for drinking water
†Ft. Galesburg...	....	881	47	622	M.	Drift wells and artesian wells	General use..........
Gardner	....	......	......	....	......	Private wells.......	No system ....
Geneva	5	200	41	$1\frac{1}{2}$	M.	Artesian well	General use..........
Gibson City	2	100	75	....	M.	Deep well..........	" ....
Gilman	....	......	......	....	......	....	No report ....
Girard	....	......	......	....	......	Deep wells	No system ....
Greenfield	....	......	......	....	......	Wells	" ....
Greenview	....	......	......	....	......	....	No report ....
Griggsville	....	......	......	....	......	Wells and cisterns.	No system ....
Havana	....	450	69	144	M.	Drift wells	General use..........
Henry	....	......	......	....	......	....	No system ....
*Hinsdale	12	300	58	275	M.	Artesian wells	Not reported.........
*Jacksonville	21	640	21	....	M.	Artesian wells, 3,627 feet deep and storage	" ....
*Jerseyville	5	110	16	50	M.	Artesian well, 3,207 feet deep	....
Joliet	* 25	2,500	43	3,000	M.	Artesian and drift wells.............	Water supply inadequate and subject to sewage contam.
Kangley	....	......	......	....	......	....	No report ....
*Kankakee........	16	1,002	37	850	P.	Kankakee river....	Not reported ....
Knoxville.........	4	90	24	25	M.	Artesian well, 1,360 feet deep	General use ....
*Lacon............	5½	200	62	30	M.	Open well near Illinois river.........	Not reported; general use ....
Ladd..............	....	......	......	....	......	....	No report ....
*LaHarpe	2	30	9	....	M.	Well	Not reported ....
LaSalle	* $17\frac{1}{2}$	1,175	56	1,433	M.	Springs and wells..	General use..........
LeRoy	* 2	70	21	38	M.	8-inch drift well 90 feet deep	" ....
*Lewistown	$5\frac{3}{10}$	165	33	80	M.	Wells	Not reported.........
Lexington	4	75	27	....	M.	Well	General use..........
Lincoln	17	......	......	....	P.	Salt creek	General use but conditions suspicious.
Lockport	* 1	* 60	11	....	*P.M	Artesian well	Not used for drink; shallow wells used.
Macomb	* $4\frac{1}{2}$	200	19	100	M.	Artesian well, 1,600 feet deep	High in minerals: not in general use; drink water from private shallow wells ....
Maroa.............	* 4	150	62	$1\frac{3}{10}$	M.	Well	General use..........

Water Supply Statistics—Continued.

City.	Miles of mains.	Water takers.	Per cent of population supplies.	Daily consumption 1,000 gallons.	Ownership.	Source of Supply.	Remarks.
Marseilles						Private artesian wells	No system for domestic use
Mason City							Not reported; for fire protection only
McHenry							No report
*Mendota	12½	600	80	36	M.	Artesian well, 400 feet deep	Not reported
*Milford	4				M.	Drift wells	"
*Minonk	1½			60	M.	Deep and drift wells	"
Momence	* 7	125	31	12	M.	Kankakee river	Generally used in winter, but not in summer
*Monticello	5½	265	67	80	M.	Wells 212 ft. deep	Not reported
Morgan Park	*10	400	86	360	M.	3 artesian wells 1315 to 1600 ft. deep	General use
*Morris	7½	305	36		M.	Artesian wells	Not reported
Mowequa							No report
*Mt. Pulaski	6	200	61		M.	Drift wells	Not reported
Mt. Sterling	2	40	10		P.	Storage reservoir	Not used for drink; water becomes foul in summer
Naperville							No system
Nilwood							No report
Normal							"
Odell							"
Onarga	¾	50	20		P.	Art'n. well in drift.	General use
Ottawa	*25	650	31	335	M.	Artesian wells	"
Pana	*10	400	36	120	M.	"Wells"	General use; also private wells
Pekin	*11	1,400	83		P.	Drift wells	General use
*Peoria	84	5,500	47	4,000	P.	Wells	Not reported, general use
Peotone	1½	30	15	22	M.		Not reported
*Peru	12	600	44	228	M.	Artesian wells 1365 ft. deep	"
Petersburg	5	150	27	*700	M.	Well near bank of Sangamon river	General use
*Plano	3	150	46	15	M.	Well	Not reported
Pontiac	*5	210	25		P.	Vermilion river	Not used for drink. No purification attempted
Princeton		500	62	200	M.	Artesian wells	General use
Ridgely						Wells	No system
Riverton							No report
Roodhouse							"
Roseville					M.	Wells	Not reported
Rushville					*M.	Wells	"
Sheldon						Artesian well	"
Springfield	58	2,500	37	4,000	M.	Sangamon river—through filter gallery	Gen. use and quality reported good
Spring Valley					M.		Not reported
St. Anna					M.		"
St. Charles							No report
*Streator	24	1,600	57	1,300	P.	Vermilion river	Not reported
Taylorville		700	82	700	M.	Drift wells 100 ft. deep	General use
Toluca							No report
Toulon							"
Utica		80	35		M.	Artesian well	General use
Vermont							No report
Virden							"
Virginia City						Wells and cisterns	No system
*Washington	2¼	125	43		M.	Drift wells 82 ft. deep	Not reported
Watseka					M.	Drift wells about 100 ft. deep	"

Water Supply Statistics—Concluded.

City.	Miles of mains....	Water takers	Per cent of population supplied..	Daily consumption 1,000 gallons.....	Ownership........	Source of supply.	Remarks.
Waverly..........	....	......	.....	....	.....	....	No report ....
W. Chicago.......	5	230	61	40	M.	Artesian well	Good—general use..
Wenona...........	....	150	50	78	M.	Artesian well 1850 ft. deep...........	General use..........
Wheaton	....	230	49	57	M.	10 in. artesian well 176 ft. deep	" ....
Whitehall	....	......	......	....	......	....	No report............
Wilmington	....	......	......	....	......	Private artesian wells 750 ft. deep.	No system for domestic use.........
Winchester.......	....	......	....	....	......	....	No report...........
Wyoming.........	....	......	......	....	......	....	" ....

* Statistics taken from Engineering News Water Works Manual, 1897, the latest available information.

† Data given for entire city.

The foregoing statistics of water supply shows 137 cities and villages upon the Illinois river drainage basin within the State, each having 1,000 or more inhabitants. Of these, eighty-five are known to have some kind of a system of public water supply, or water works, including water mains supplying more or less of the population with some kind of water—seventy-four of these systems are owned by the municipalities supplied and twelve by private corporations. In many instances good, wholesome water is supplied and in many others it is unfit and unsafe for domestic use, especially for drink. In such cases, wells located on the premises or cisterns for storing rain water are relied upon for drink and culinary purposes. Of the eighty-five cities supplied, forty are known to use the public supply for drink. A considerable number report the water not used for drink on account of excess of minerals in many artesian waters, and organic matter in surface waters stored in open reservoirs and water taken from streams. From this it appears that about half of the public water supplies are, for one reason or another, not acceptable to the inhabitants to whom it is supplied. This apparently large percentage would no doubt be reduced by more complete data. Furthermore, in the larger cities a large part of the people use the public water supplies for drink and domestic purposes, so that the total percentage of population having a public water supply available and not using the same for domestic purposes is considerably less than the figures above would seem to indicate.

In the northern portion of the State the porous sandstone strata which are of great thickness and lie near the surface, cropping out in numerous localities and being exposed over a large area of southern Wisconsin, furnish large quantities of wholesome water, practically free from organic matter and not having an excess of minerals. In the valley of the Illinois river great deposits of washed sand and

gravel have been left by the ancient stream and these deposits which cover miles of territory carry large quantities of water which are available—as at Peoria and Pekin, and for many miles above and below these cities. The artesian waters found at depths of 1,800 to 3,000 feet throughout the central and southern portions of the State are heavily charged with minerals, especially salt and sulphur and are not satisfactory for either domestic or manufacturing purposes. The central portion of the State is overlaid with the more recent glacial drift. In this drift, at variable depths of from 10 to 300 feet, a limited supply of water, sufficient for farm use and for smaller villages, is found quite generally distributed, so that the territory is regarded as well watered. The southern portion of the State is not so fortunate in even a limited supply of water. The drift of that region is a compact clay with few sand strata or pockets, and the drainage lines are well worked out so that the larger rainfall only runs off the more rapidly.

Speaking generally, therefore, for the whole state as well as for the Illinois river basin, the larger cities, excepting such as are in the northern portion where the Potsdam and St. Peter's sandstone formations are comparatively near the surface and in the Illinois river valley are dependent upon surface water for their public supply. Twelve cities having a total of 143,600 inhabitants located on the Illinois basin take water from the streams or storage reservoirs:—Two from the Kankakee; one from the Fox; two from the Vermilion; five from the Sangamon and its tributaries, and two from smaller streams. Of these supplies, two are filtered by mechanical filters, viz., Elgin and Decatur, and two take the water by infiltration—from the river to galleries at Springfield, and to wells at Petersburg. Before the Chicago sewage was turned into the Illinois river the City of Peoria took its water supply from the river.

Eighteen cities, having a total of 165,000 population, are supplied in whole or in part from shallow wells. Of these Peoria, Pekin and Joliet, having a total of 96,000 population, are within the two excepted classes, Joliet having within its reach an artesian supply and Peoria and Pekin being in the valley of the Illinois. Bloomington is the only city of more than 5,000 inhabitants depending upon water from the glacial drift. Galesburg draws from wells in glacial drift and two artesian wells which furnish highly mineral water. The total population on the Illinois river basin having public water supplies from drift wells as appears by reports at hand is about 45,000.

This review brings out the importance of our surface waters as sources of supply for domestic and manufacturing purposes. The data at hand indicates that considerably over half of our urban population, exclusive of Chicago, is dependent upon surface waters, or those very near the surface and subject to the same influences, and the ratio will increase with the increase of population and manufacturing.

The following table gives the urban population on the various subbasins of the Illinois river for 1890 and 1900, also the per cent of urban to the whole population. From the statistics on water supply

the number of gallons of water supplied per capita per day to the urban population on each sub-basin has been estimated. By taking the amounts reported and determining the per capita supply, then applying this amount to the total urban population, the total water supplied was determined. The last column shows the cubic feet per second equivalent to the water supplied to the population on each sub-basin and on the entire area.

Illinois River Drainage Basin—Table of Urban Population and Water Supply Statistics.

Drainage Basin.	1890.		1900.		Estimated gallons water supplied. Per cap per day.	Estimated total gallons water supplied per day.	Equivale't flow in cubic feet per second.
	Urban Pop.	Perce't Urban Pop.	Urban Pop.	Perce't Urban Pop.			
*Des Plaines	49,355	49	70,748	57	99.3	7,025	10.86
Du Page	5,344	28	6,851	31	23.1	158	0.24
*Kankakee	35,450	20	44,681	23	53.2	2,377	3.66
*Fox	69,166	42	81,743	47	47.3	3,866	5.96
Vermilion	21,085	33	27,631	40	70.1	1,937	2.99
Mackinaw	8,781	20	10,924	23	37.1	405	0.62
Spoon	22,056	29	28,519	35	40.0	1,141	1.76
Sangamon	101,585	38	133,632	44	91.4	11,215	17.28
Crooked Creek	11,853	21	14,344	26	13.9	199	0.30
McKee's Creek	5,238	31	5,624	34	32.0	180	0.28
Macoupin Creek	13,023	29	15.778	34	32.0	505	0.77
Pop. directly trib to Ill	139,134	42	177,189	47	65.5	11,606	17.89
Peoria industries (est'd)	....	....	....	....	....	15,000	23.11
Totals	482,070	35	617,664	41	65.7	55,614	85.72

*Census for Indiana and Wisconsin in 1900 not at hand, and that of 1890 used.

The DesPlaines, Fox, Sangamon and Illinois direct have the largest per cent of urban population; the Kankakee and Mackinaw the smallest; the DesPlaines with 49 per cent in 1890 and 57 per cent in 1900 being high, and the Mackinaw and Kankakee each having 20 per cent in 1890 and 23 per cent in 1900. The average for the entire Illinois basin was 35 per cent in 1890 and 41 per cent in 1900.

The maximum *per capita* supply is 99.3 gallons per day on the Des Plaines and 91.4 gallons per day on the Sangamon, while on some of the smaller sub-basins the supply is very small; Crooked creek for example falling as low as 13.9 gallons *per capita* per day. The average supply *per capita* per day for the entire basin is 65.7 gallons, and the estimated equivalent flow is 85.72 cubic feet per second which includes 23.11 cubic feet per second estimated for Peoria industries and not included in the water supply of Peoria. Of the total amount the DesPlaines basin contributes 10.85 cubic feet per second; the Fox 5.96 cubic feet per second; the Sangamon 17.28 cubic feet per second, and the Illinois direct 41.0 cubic feet per second. These data will be referred to further on in the discussion on sewage.

Sewerage.

With the questions asking information regarding the water supplies, another list of questions regarding sewers was sent. These questions were as follows, viz:

QUESTIONS REGARDING SEWERAGE AND SEWAGE DISPOSAL.

1. Number of miles of sewers?

2. Number and size of outlets and into what do sewers discharge?

3. What method of sewage disposal or treatment, if any, now in use or heretofore tried?

4. What improvements are considered necessary or in contemplation?

5. How many houses connected with sewers?

6. What manufacturing industries, if any, are using sewers or streams for drainage of refuse and what is the character and extent of the refuse or sewage thus discharged?

The following table gives the principal data gathered, in response to the foregoing questions regarding sewerage systems thoughout the Illinois river basin. The tabulated data are: (1) number of miles of sewers; (2) number of house drains; (3) character of construction; (4) method of disposal, and (5) condition of system:

Sewerage Statistics of Cities on Drainage Basin of Illinois River.

City.	Miles of Sewer......	Number of House Connections....	Construction.	Disposal.	Remarks.
Assumption					No system
Atlanta			Drain tile		City well drained with drain tile but no sewerage system
Aurora	60	3,440	Brick and pipe	Fox River	
Batavia	3	40	10 to 18 inch pipe and brick sewers	"	State discharges sewage into Fox River above Batavia
Bement					No system
Bushnell	3	25	2-10 inch drain tile as sewers	Small braneb	Need new system
Canton	$11\frac{2}{3}$	300	Brick and pipe	Creek tributary to Spoon River	
Carrollton					No system
Carthage					Sanitary sewers
Clinton	8		Pipe (30 inch)	Creeks	
Colchester	2		24 inch drain tile outlet to branch		Used only for land drainage
Decatur	30		Brick and pipe	Sangamon River	Numerous factories drain into the sewers
Delavan	$\frac{1}{4}$	6	12 inch pipe	Creek	
Dundee					Private sewers not described
Earlville				Cesspools	No system
El Paso					"
Eureka					"
Fairbury					"
Farmer City					"
Farmington					"
Forrest					"
Galesburg	20	3,000	Brick and pipe	Cedar Fork Creek	Need an out fall sewer and disposal works
Gardner					No system
Geneva	$\frac{2}{3}$	15	12 inch pipe	Fox River	Private sewer
Gibson City			Tile drains		No sewerage system
Girard			Open ditches		No system
Greenfield					"
Griggsville					"
Havana	$1\frac{1}{4}$	58	Pipe	Illinois River	
Henry					No system
Joliet	20	900	Brick and pipe	Ill. and Mich. C. and Des Plaines R.	Open drains carry a large part of the sewage through the city from prison and factories

Knoxville	5		6 to 12 inch drain tile	Branch	Used for cellar drains and Seminary laundry sewage
Lacon					No system
LaSalle	11½		Brick and pipe	Ill. and Mich. Canal and Ill. River	
LeRoy					No system
Lexington	2½	25	12 and 24 inch outlets		
Lincoln	25			Salt Creek	
Lockport				Illinois and Michigan Canal	Factories use Illinois and Michigan Canal and Des-Plaines River
Macomb	4	97	15 and 18 inch pipe sewers	Creek	Some system of disposal contemplated
Maroa					No system
Marseilles					No system, paper mills to river
Momence	2		12 and 24 inch pipe	North channel of Kankakee River	Sewage emptied into drainage channel and in summer becomes a nuisance
Mt. Sterling	2½	40	18 inch pipe sewer	Branch	
Naperville					No system
Onarga					"
Ottawa	4	550	Brick and pipe	Fox and Illinois Rivers	
Pana					No system
Pekin	⅓		Brick (5 feet)	Illinois River	Complete system needed
Peoria	70		Brick and pipe	"	
Petersburg	1	50	14 inch pipe	Sangamon River	
Pontiac	5	220			State Reformatory, shoe factory, etc., drain into system
Princeton	1¼				System built during 1900, with filter beds for disposal
Roodhouse			Drain tile		No sewerage system
Springfield	48	3,000	Brick and pipe	Branch	Brewery, gas works, woolen mill and soap factory use sewers
Taylorville	5½	160	Pipe (18 inch)	Sangamon River	Packing house, gas works, strawboard mill., etc., all drain into river
Turner					No system
Utica					"
Virginia City	1	Many	Drain tile		Presumedly drain tile and cellar connections
West Chicago					Surface drainage
Wenona			Drain tile	Branches	No sewerage system
Wheaton					No system
Wilmington		3	Drain tile	Branches	Private drains

The data is meager. Sixty-two reports were received, twenty-six of which reported 'no system" and eight reported tile drains for subsoil drainage, the remaining twenty-eight reporting more or less complete sewerage systems. Several of the larger cities are not included in the list as there is no data at hand regarding their sewerage systems. There are, no doubt, many villages having land drains which are not reported. Generalizations are not practicable from the data at hand; only these, first, that sewerage facilities are not generally available excepting in the larger cities; and second, that open jointed land drains are frequently used for sewage—a practice which will result in serious contamination of the surrounding earth, near-by cellars and wells, and sooner or later will bring upon those who are compelled to live where sanitary laws are thus violated the unfailing penalty of weakened constitutions, disease and often premature death.

The cities having sewerage systems all dispose of their sewage by discharging into streams. There are a few cities in the State which have made more or less satisfactory arrangements to purify the sewage but no general voluntary movement in this direction is apparent. On the contrary, every community seems to regard itself as having made great progress in sanitation when it has prepared to unload its own refuse, even at the peril of the life and health of its nearest neighbor. This, in fact, is a long and difficult step, but in populous areas proper sanitation is only half accomplished when the sewage and garbage have been brought to a central point or points for final disposal. Such disposal should be made as will not interfere with the health, life and pursuits of others. The streams are the drainage channels of the land and must receive the sewage, but the tendency and growing demand of the hour is to require the producer of sewage, refuse and garbage which may be deleterious to health and comfort, to so treat and dispose of these waste products as to reduce the injury to others to a minimum

Referring again to the statistics on water consumption, or as supplied to the urban population on the various drainage basins of the Illinois, it is noted that the Des Plaines, Fox, Sangamon and Illinois direct contribute 88 per cent of the water consumed. Basing the sewage producing capacity on this data, the localities now subject to the most contamination are readily discernable, and special study of the conditions of each locality is necessary to a correct determination of their several requirements.

Taking the water supplied to all the cities of the Illinois as 85.72 cubic feet per second as compared with the estimated flow of 600 cubic feet per second from the Illinois and Michigan canal as Chicago's contribution of sewage the latter delivers seven times as much sewage to the Illinois river as all other cities combined. Allowing reasonably for manufacturing sewage not accounted for the ratio is more likely as 6 to 1. The population of Chicago is 2.75 times that of the urban population tributary to the Illinois. The daily per capita water consumption in Chicago is more than double that of the State outside Chicago making a close check on the above data. All of the water supplied to users does not, of course, reach the streams, on account of the evaporation and other uses to which it

is put and the lack of sewage facilities in many of the smaller places, but a large percentage of the water does reach the streams as sewage after having passed through natural and manufacturing processes. There is also a large amount of sewage produced which is not from water supplied by public works. Taken then as a measure of relative as well as actual sewage pollution of streams the water supplied is the best data at hand or readily obtainable.

The evidence of the importance of an abundant supply of wholesome water to the city of Chicago can not find much stronger expression than in the statement of cost of construction up to the present year:

Water works system, in round numbers	$30,000,000
Sewerage system in round numbers	20,000,000
Main drainage canal, in round numbers	35,000,000
Total	$85,000,000

That vast sum represents an investment of something over fifty dollars per capita for those two branches of the public service, and plans are now being matured which, when carried out, will cost Chicago $30,000,000 to $40,000,000 more before a satisfactory condition as to the shipping interests and compliance with the law in the matter of dilution can be finally accomplished.

In summing up the results of this preliminary survey of the Illinois river basin, it becomes apparent that the first interest centers in the effect of the Chicago sewage upon the waters of the Illinois river. This question is not confined to the effect of such sewage at any particular point, as for example at the mouth of the river, but must be regarded in its influence upon the river throughout its entire course. Furthermore, the effect of the sewage from other cities located on the Illinois and its tributaries can not be neglected. The data brought together in this report is intended to be of such nature as to be useful in the further development of the sanitation of this territory, which is growing more populous from year to year and in which the magnitude of manufacturing interests is rapidly increasing. The meaning of this is, that, sooner or later, the entire upper valley of the Illinois river (above the Sangamon), may some day be compelled to expend enormous sums of money, as Chicago is now doing, to get relief from this ever increasing amount of domestic sewage and manufacturing wastes.

Foreseeing, therefore, in some small degree what the promise of the future would be from a sanitary point of view should the present methods of sewage disposal be persisted in, it stands the sanitary authorities of the commonwealth in hand to note well these conditions and find means for safely and economically overcoming and rendering harmless the disease producing and generally obnoxious and profitless wastes of life processes and of human industry.

Respectfully submitted,

JACOB A. HARMAN.

PEORIA, ILL.,
March, 1901.

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